

PAGES 2nd Open Science Meeting - Abstract Book



*Paleoclimate, Environmental Sustainability and our
Future*

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Paleoclimate, Environmental Sustainability and our Future



PAGES 2nd Open Science Meeting - Beijing, China 10 -12 August 2005

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Prologue: Welcome to the 2nd PAGES - OSM in Beijing

PAGES (Past Global Changes) was founded in 1991 as a core project of the International Geosphere-Biosphere Programme (IGBP). Since its inception, PAGES has served the paleoscience community by supporting research aimed at understanding the Earth's past climate and environment, with the ultimate aim of assisting future predictions. While the specific themes have shifted over the years, the underlying role of PAGES has always remained that of an integrative mediator between paleoscience disciplines and communities.

PAGES 1st Open Science Meeting was held in London in 1998. By holding its 2nd Open Science Meeting in Beijing and embracing researchers and groups from the Asian region, PAGES takes another major step towards strengthening the international paleoscience community. Better integration of the active and growing Asian community will undoubtedly be of immense benefit and vital importance to the field of paleoscience during the years to come.

This meeting is designed to encourage interaction between scientists on all levels, disciplines and regions. The hope is that many contacts will be made, and many collaborations and joint activities begun that will endure long after the meeting itself. This would truly round out this meeting as a milestone in the history of PAGES.

We would like to take this opportunity to thank our Chinese hosts for enabling us to meet here in Beijing. We are extremely grateful to them for the tremendous effort they have made in organizing the meeting. We would also like to express our deep appreciation to the various funders of the meeting for their generous support.

We wish everyone a productive and stimulating meeting, and a very pleasant stay in Beijing.

Thorsten Kiefer, Leah Christen and Christoph Kull

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Acknowledgements: OSM Organizing Committees

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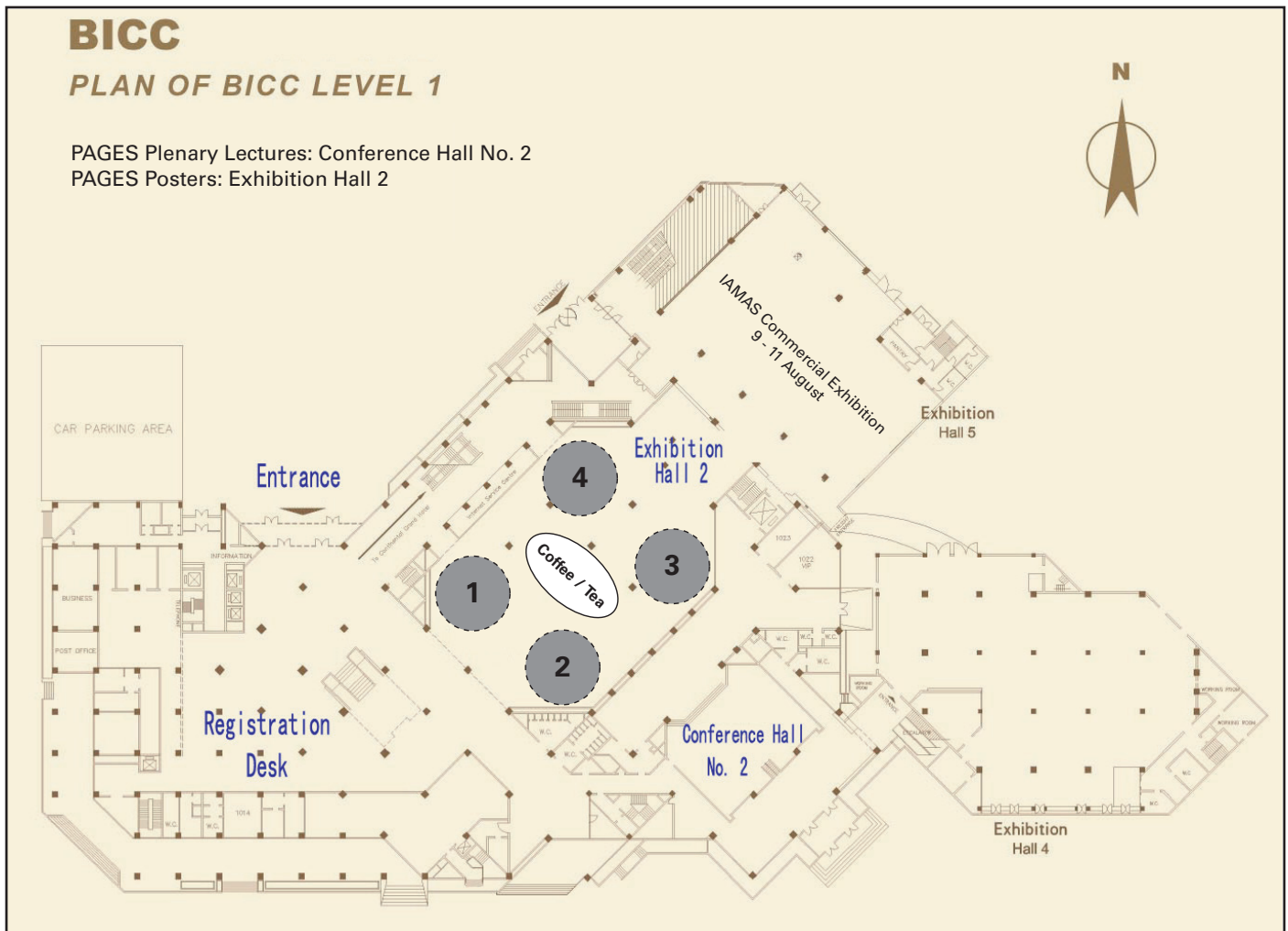
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- National Oceanic & Atmospheric Administration
- IGBP: International Geosphere-Biosphere Programme
- DST: Indian Department of Science and Technology
- APN: Asia-Pacific Network for Global Change Research
- START: System for Analysis, Research, and Training
- TWAS: Academy of Sciences for the Developing World

Floorplan - Beijing International Convention Center



Information

Legend:

- 1) Poster Session 1: Future Change - Historical Understanding
- 2) Poster Session 2: Humans and their Environment - Past Perspectives on Sustainability
- 3) Poster Session 3: Ocean-Continent-Cryosphere Interactions - Past and Present
- 4) Poster Session 4: Climate, Humans and the Environment in Asia

A meeting area for recipients of APN funding is located in the poster hall.

IAMAS 2005 Scientific Assembly

2 - 11 August

Symposia: Levels 2 and 3

Posters: Level 2

Commercial Exhibition: Level 1 - Exhibition Hall 5

Session 1: Future Change - Historical Understanding

One motivation to investigate past environmental conditions is to draw conclusions about future change that could not be drawn from short present-day observations alone. Research presented in this session focuses on high-resolution and high-precision reconstructions from the last centuries and millennia before the instrumental record. Contributions to this session put observations of present-day global change and predictions on future change into the perspective of natural climatic and environmental variability. Studies presented here also aim towards a better understanding of the climate system, or parts thereof, in order to equip predictive approaches, such as climate models, with increasingly realistic process modes

Plenary Lectures:

p. 10 - 15

Poster Abstracts:

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First Author Index:

p. 176 - 179

Insights from comparing empirically-estimated and modeled climate change in past centuries*Michael Mann*

Both reconstructions from climate 'proxy' data (e.g., tree rings, ice cores, corals) and climate model simulations, suggest that late 20th century warmth is anomalous in the context of the past 1,000-2,000 years. Various alternative reconstructions differ in their details however. Many of these differences appear to be related to issues of seasonality and spatial representativeness. Statistical methodologies for reconstructing past large-scale temperatures from proxy data have now been tested using a long forced simulation of the NCAR CSM 1.4 coupled model. Analyses of synthetic 'proxy' networks produced from the model suggest that existing proxy-based climate reconstructions are likely to yield reliable estimates of past temperature variations within estimated uncertainties. Important differences between estimates of extratropical and full (combined tropical and extratropical) hemispheric mean temperature changes in past centuries appear consistent with seasonal and spatially-specific responses to climate forcing. Forced changes in large-scale atmospheric circulation such as the NAO, and internal dynamics related to El Niño, may play an important role in explaining regional patterns of variability and change in past centuries.

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Interhemispheric linkages in climate change: Paleo-perspectives on modern problems

James Shulmeister

The PANASH program has significantly advanced our understanding of past climate change on a global basis and helped to integrate paleoscience across regions and between disciplinary specialists. PANASH science allows us to constrain predictions for future climate change and to contribute to the management and mitigation of such changes. We identify three broad areas where PANASH science makes key contributions: 1. Insights into global climate drivers through the recognition of patterns and timing of global changes. The global synchronicity or otherwise of glacial advances during the last glaciation is critical to understanding inter-hemispheric links in climate. Work in PEP I demonstrated that the tropical Andes in South America was deglaciated earlier than the northern hemisphere (NH) and that an extended warming occurred from c. 21,000 cal years BP. The general pattern is consistent with Antarctica and has now been replicated from studies in southern hemisphere (SH) regions of the PEP II transect. That significant deglaciation of SH alpine systems and Antarctica led deglaciation of NH ice sheets may reflect either i) faster response times in the former, ii) regional moisture patterns that influenced glacier mass balance, or iii) a SH temperature forcing that led changes in the NH. 2. The recognition and definition of longer-term changes in modes of operation of climate phenomena. Work across all the PEP transects has led to the recognition that the El Niño Southern Oscillations (ENSO) phenomenon has changed markedly through time. It now appears certain that ENSO either did not operate, or operated in a greatly reduced mode during the last glacial termination and during the early Holocene. In the modern ENSO phenomenon both inter-annual and seven-year periodicities are present, with the inter-annual signal dominant. Paleo-data demonstrate that the relative importance of the two periodicities changes through time, with seven-year periodicities dominant in the early Holocene. 3. The recognition of climate modulation of oscillatory systems by abrupt climate events. We will describe interactions between ENSO and the tropical oceans during the early Holocene. We also examine the role of ENSO and other oscillatory climate systems in controlling the manifestation of an abrupt SH climate event, the Antarctic cold reversal (ACR), in the New Zealand region. PANASH (Paleoclimates of the Northern and southern hemisphere) PEP (Pole-Equator-Pole transects in the PANASH program; PEP I – Americas; PEP II – East Asia-Australasia; PEP III – Europe-Africa)

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Long-term variability in tropical and high-latitude circulation modes of climate in the Americas*Ricardo Villalba*

Climate-induced changes in the amount and quality of natural resources are critical determinants of human activities across the Americas. An increasing number of analyses of instrumental data indicate that the climate system fluctuate at many different temporal scales. For example, ENSO and PDO are respectively linked to the interannual- and decadal-scale climatic variability in the tropical Pacific. The dominant modes of climate variability at higher latitudes, such as the Arctic and Antarctic Oscillations, also exhibit short- and long-term modes of variability. Meteorological records are short, severely restricting the study of decadal-scale oscillations and the interactions between interannual and long-term modes of climate variability. High-resolution records (i.e., tree-rings and corals) provide temperature- and precipitation-sensitive records of past climate fluctuations that can be used to examine the temporal and spatial patterns of decadal climatic variability along the western the Americas during the past centuries. A combination of exactly dated tree-ring chronologies from a treeline transect paralleling the western coast of the Americas and coral records from the tropical Pacific were used to track those past climatic variations in the Pacific that have simultaneously impacted the extratropical regions of North and South America. Significant correlations between temperature reconstructions from Alaska and northern Patagonia with Raratonga Ca/Sr coral-record suggest the existence of an interdecadal oscillatory mode for temperature variations across the Pacific basin during the past 3-4 centuries. Tree-ring chronologies from precipitation-sensitive regions also reveal interannual to decadal-scale oscillations, centered at 3.6 and 10-15 years, which have simultaneously influenced climatic conditions in the Midwest-Southern United States, the Bolivian Altiplano and Central Chile. Spatial correlation patterns between tree-ring records and sea surface temperatures (SST) show that variations in climate-sensitive records are strongly connected with SST anomalies in the equatorial Pacific and off the western coast of subtropical America. These correlation patterns resemble the spatial signature of ENSO and PDO over the Pacific. For the past 400 years, striking similarities in temperature fluctuations are observed in the Arctic and sub-Antarctic regions. The most notable feature of temperature change revealed by most high-latitude records is the continuous transition from anomalous cold conditions in the mid-19th century to anomalous warm in the mid-20th century. In contrast, global and hemispheric mean temperatures show almost no trend between the late 1850s to the 1910s, suggesting that high latitudes in both hemispheres share common patterns of temperature changes that may not be present at global scales.

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Dynamics of climate and water cycle changes: Interest of quantitative climate reconstructions*Valérie Masson-Delmotte*

The awareness that climate has changed in the past has emerged from our capability to date past environmental changes and quantify the magnitude of climate change together with its consequences on the local ecosystems. Instrumental records are too short—at best a few centuries—to capture the full spectrum of climate variability. They have to be complemented by a variety of proxies in a variety of archives. These indirect climate indicators have to be calibrated against climatic parameters, the various sources of biases have to be identified and quantified. Most quantitative efforts have been dedicated to the reconstruction of past temperatures. Quantitative temperature reconstructions enable to estimate not only local climatic changes but the aggregation of local records to provide regional to hemispheric estimates, which are critical for the comparison between observed and modeled past climate changes and to understand the mechanisms of climatic changes. Water cycle changes are deeply involved in many feedback processes within the climate system, ranging from short spatial and temporal scales associated with cloud radiative properties to large scales associated with snow and ice albedo feedbacks. Polar regions represent the cold point of the climate system. They are both sensitive to climate change and actors of climate change due to polar amplification processes, contributions to sea level changes, and interactions with atmospheric and ocean circulations. Several methods enable to reconstruct past temperature changes from polar ice cores. I will show the state of the art to quantify polar temperature changes at various timescales and discuss past changes in water cycle recorded in polar ice cores. Owing to these quantitative temperature reconstructions, the capacity of coupled climate models to capture past climate changes in polar regions will be discussed.

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Climate sensitivity derived from PMIP-2 model-data intercomparisons for the Last Glacial Maximum and Mid-Holocene

Bette Otto-Bliesner

Climate models are tuned to reproduce the current mean climate state. Their ability to predict the large climate changes of the future can be critically assessed with the large forcings of past climate states. The Paleoclimate Intercomparison Project (PMIP) is a long-standing initiative endorsed by the World Climate Research Programme (WCRP; JSC/CLIVAR working group on Coupled Models) and the International Geosphere and Biosphere Programme (IGBP; GAIM and PAGES). The second phase of PMIP (PMIP-2), launched in Autumn 2003, is evaluating fully-coupled ocean-atmosphere and ocean-atmosphere-vegetation models in simulating the climates of the mid-Holocene (6000 years before present) and the Last Glacial Maximum, LGM (21,000 years before present). In this talk, I will present results of coupled simulations of the mid-Holocene and LGM that have been done at modeling centers worldwide using a standard set of forcings and boundary conditions for these two time periods. Model-model intercomparisons address climate sensitivity, the role of ocean, land-surface and sea-ice feedbacks, and interannual to multi-decadal variability that can be compared to predictions of future climate change of these coupled models. Model-data comparisons provide benchmarks of the model simulations, particularly the ability of these coupled models in capturing shifts in vegetation associated with past changes in the mean climate and its variability and in reproducing changes in the surface and deep ocean and associated thermohaline circulation. PMIP results formed a crucial part of the evaluation of climate models in the Third Assessment Report of the Intergovernmental Panel on Climatic Change (IPCC) and will contribute importantly to the IPCC Fourth Assessment Report (AR4). The extensive model-model and model-data comparisons for the LGM and mid-Holocene of PMIP-2 will provide another metric for constraining climate sensitivities of the models included in AR4 assessment of future change. Key results and diagnostics from PMIP-2 that are relevant for future climate change and that will help us evaluate models used for IPCC-AR4 scenarios will be discussed.

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Past climate variability at centennial-to-millennial timescales: Does it matter for predicting future climate change?*Michael Schulz*

Climate change at millennial timescale is best known from the last glacial period, when so-called Heinrich events and Dansgaard-Oeschger cycles perturbed the climate system. These climate fluctuations were associated with rapid (i.e., happening in a decade or even less) and large-amplitude transitions in Atlantic Ocean's thermohaline circulation and impacted climate at least at an hemispheric scale, more likely even globally. While the origin of the Heinrich events was traced to internal instabilities of continental ice caps, the cause for the Dansgaard-Oeschger cycles remains elusive. Recently, Dansgaard-Oeschger events have been tentatively linked to external forcing mechanisms, mainly because of their regular pacing ("1500-year cycle") which seems difficult to reconcile with an Earth-bound origin. Based on experiments with an ocean-atmosphere-sea ice model of intermediate complexity it is argued that Dansgaard-Oeschger cycles are generated within the Earth climate systems and do not necessarily call for an external origin. These model experiments reveal that the coupled climate system can exhibit unforced climate variability at centennial-to-millennial timescales. The modeled oscillations are associated with on- and off-states of deep convection in the Labrador Sea while convection in the Norwegian-Greenland Seas remains active during all phases of the oscillations. The oscillations represent a three-dimensional phenomenon, linked to the intricate interaction between two deep-water formation sites in the North Atlantic. A widely held view is that the rate of North Atlantic deepwater production may weaken (or even cease) during the next century due to anthropogenic climate forcing. Based on our modeling results, we add to this complexity by suggesting that future climate may be associated with the renewed onset of oscillations of the Atlantic Ocean's thermohaline circulation.

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A climate record for the last 40 ka around the northern Japanese Alps region, central Japan

Danda Pani Adhikari, Fujio Kumon, Satoshi Koshimizu

To reconstruct the climate for the last 40 ka in central Japan, sediment cores extracted from Lake Aoki were investigated for grain-size, diatoms, total organic carbon (TOC), and total nitrogen. An abrupt decrease in sand and clay contents and increase in TOC flux and diatom abundance at 13 ka cal BP is interpreted as the last Glacial/Holocene boundary. TOC flux and diatom abundance are closely positively correlated in both short- and long-term fluctuations. Changes in surface water temperature and paleohydrology appear to be the main factor affecting the variability in the proxy records. Glacial cooling, with a series of fluctuations, lasts until 13 ka cal BP. More cooling events, centered at ca. 16, 28, 34, and 39 ka cal BP, can be correlated with Heinrich events H1, H2, H3 and H4, respectively. The Last Glacial Maximum reaches its maximum ca. 22 ka cal BP. Beginning with a rapid warming, the Holocene climate history is characterized by an alternating sequence of seven warm and seven cool phases, with abrupt transitions and lengths lasting from hundreds to thousands of years. Climatic events such as the Little Ice Age (LIA), the Younger and Older Dryas, the Medieval Warm Period, and the Holocene Optimum are evident, and some other warm and cool events not previously well recorded are also apparent. Generally, the Holocene was warmer than the present time but cool periods even colder than the LIA are also observed. The magnitude of climate change observed after the LIA was commonplace in the Holocene.

LAKE AOKI, ORGANIC CARBON, DIATOM, HOLOCENE OPTIMUM, LAST GLACIAL AGE

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Preliminary results on the presence and distribution of heavy metals in bottom sediments in Guanabara Bay, Brazil

Paola Almeida, Maurizio Bonardi, Guido Perin, Stefano Covelli

High levels of pollution have been recorded in coastal zones as a consequence of uncontrolled anthropogenic activities taking place in these areas. Guanabara Bay, Rio de Janeiro, Brazil is no exception and is now under great pressure due to recent and fast urbanization and industrialization of the area and surroundings. In order to get an idea of the degree of pollution caused by domestic sewage, industrial discharges, and other activities like agriculture and

intensive maritime traffic caused by the presence of important ports in the area and tourist boats, a series of geochemical, geological, mineralogical and chemical analyses were performed on the bottom sediments of the Bay where most discharges have accumulated. The first geochemical and geological results come from analysis of superficial sediment samples and sediment cores (50-55 cm), and confirm high levels of heavy metals (HM) in the bottom sediments of the Bay. A spatial distribution of the HM concentrations, indicating the most vulnerable and polluted areas of the Bay, was made in an attempt to identify the main sources and diffusion vectors of pollutants contained in domestic (organic matter) and industrial discharges. The source of this pollution is also being traced in order to determine the possible critical period when anthropological elements excessively impacted on the natural components of the environment. For this purpose, data from the deep, pre-industrial levels of local sediment cores, which in this case may be considered the most suitable baselines, were also analyzed, and in this way establish the natural conditions before the majority of the pollution took place. However, considering the textural variability of the sediments (higher than the single baseline levels) regional normalization functions (trace element vs. grain-size proxy) are the best choice. Here, we propose a geological-environmental approach to the Guanabara Bay study, related to its pre- and post-industrial environmental conditions.

SEDIMENT, GEOCHEMICAL, HEAVY METALS, COASTAL ZONES, GUANABARA BAY

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A mid-Holocene annual-resolution ¹⁸O stalagmite record from Ethiopia

Andy Baker, Jennifer Moss, Asfawossen Asrat, Melanie Leng, Peter van Calsteren, Mohammed Umer, Claire Smith

A stalagmite from Achere Cave in the Mechara region of Ethiopia has been dated by 7 lamina-tuned TIMS U-Th dates to 4800±90 to 4250±90 BP. The sample has 451 annual visible laminations. Lamina width varies between 1.66-0.12 mm, averaging 0.53 mm, in agreement with those expected from the modern cave temperature (21°C) and drip water calcium ion concentrations (~200 ppm). Over 200 ¹⁸O isotope analyses, resolution of ~2 years, fluctuate between -2.4 to -4.5%. Variations along individual growth layers demonstrate greater lateral variation in ¹³C and ¹⁸O

than temporal variations, suggesting that the sample was deposited out of isotopic equilibrium. Spectral analysis shows that for ^{18}O there are two statistically significant periodicities: most power is between 59-81 years with a weaker periodicity of 19-21 years. Stalagmite ^{18}O is isotopically lighter than modern straw stalactites (-0.4 to -1.2‰), and than that predicted (-1.5 to -2.8‰) to form from modern day precipitation (from Addis Ababa, 175 km to the W). Modern drip data and straws all fall on the MWL, suggesting there is no modern day evaporative effect, which agrees with humidity measurements made within the modern cave environment. The isotopically light mid Holocene ^{18}O can be explained by wetter conditions in the mid Holocene, possibly due to a stronger ITCZ due to higher summer solar insolation than present.

STALAGMITE, HOLOCENE, ETHIOPIA, CLIMATE, RAINFALL

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Preliminary results of a fine-resolution study of climatic fluctuations in south-east Australia over the last 2,000 years

Cameron Barr, Peter Gell, John Tibby, Martin Williams, Geraldine Jacobsen

The climate of the last two millennia has demonstrated periods of considerable fluctuations. The Medieval Warm Period and the Little Ice Age have been the subject of numerous studies and have been well documented in the northern hemisphere. While there is a growing body of evidence from the southern hemisphere to suggest that these events were global in scale, to date, there have been no high-resolution studies emanating from the Australian mainland. Here, we present the preliminary results of a study from two volcanic crater lakes in western Victoria, in the south-east of Australia. The study has employed decadal to sub-decadal sampling of fossil diatoms, which provide a quantitative reconstruction of lake paleosalinity through the use of a modern diatom transfer function. Results are supported by a high-resolution chronology determined from Accelerated Mass Spectrometry (^{14}C AMS) of fossil pollen and ^{210}Pb dating of younger sediments. Results demonstrate

considerable fluctuations in paleosalinity over the period of the last 2,000 years, which is interpreted as evidence of climatic forcing.

CLIMATE, DIATOMS, MEDIEVAL WARM PERIOD, LITTLE ICE AGE, PALEOSALINITY

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Stable isotope records of Holocene environmental changes from Moroccan Lakes: An emerging synthesis

Abdelfattah Benkaddour, Henry Lamb, Melanie Leng, Françoise Gasse

Lacustrine sediment is one of the most interesting and reliable non-marine paleo-archives that Morocco can provide for studying climate variability and change in North Africa. The Moroccan mountains (High and Middle-Atlas) contain several small basins with natural lakes. Their geographic position makes these water bodies generally safe from anthropogenic disturbance. Fluctuations in the balance between precipitation and evaporation are translated directly into changes in lake level and salinity. The stable isotope composition and hydrochemistry of such closed-basin lakes respond directly to changes in the water budget through evaporation and concentration of dissolved salts. The sediments of these lakes contain several excellent fossils and geochemical proxies; some of which have the potential for quantitative reconstruction of past water chemistry. However, because of the small size of these lacustrine systems (few hectares to 3 km²), the local effects are amplified. These effects should thus be distinguished from climatic changes. Five lacustrine sites with eight lakes were investigated. Isotopic contents of meteoric and groundwater show that the rain-producing air masses in the Atlas Mountains have two origins: Atlantic and Mediterranean. The Local Meteoric Water Line in the Atlas is approx. $\delta^2\text{H} = 8.07 \delta^{18}\text{O} + 13$. Isotopic contents and chemistry of the lakes water are related to the local groundwater. Most of the lakes are fed by the local aquifers and seep by small downstream springs. Chloride and ^{18}O in lacustrine water reveal a clear evaporation effect. ^{18}O enrichment varies from about 1‰ (Ifni Lake) to about 14‰ (Tislit Lake). This allowed us to classify the Moroccan lakes into 3 residence time categories: short (Ifni), intermediate (Tigalmamine

and Azigza) and long (Tislit, Isli and Sidi-Ali). ^{13}C and ^{18}O contents of TDIC and biogenic carbonates are in close relation with the water residence time and the water isotopic composition. Isotopic contents of presumed authigenic carbonate are to be taken with care. Moroccan lakes will have been determined by different controls and they will have responded differently to the same climate forcing.

MOROCCO, LAKES, ISOTOPES, HOLOCENE, PALEOCLIMATE

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Palynology applied to terrigenous marine sediments: A new generation of data for the Quaternary

Célia Beaudouin

Palynology is an old tool that has now been used for a century to reconstruct past vegetation dynamics. For historical reasons, it has mostly been applied to lacustrine and rarely to marine sediments. Up until now, palynologists focused their efforts on lakes. Nevertheless, in Western Europe, the high sampling pressure was only able to provide a poor database of sites recording continuously more than the last 15,000 years, while the Holocene was well documented. Only twelve long, continuous cores document several glacials and interglacials. Therefore, the spatial resolution reached by these data is too low (i.e., several hundred km) to understand past vegetation dynamics. As a consequence, two opposing models of vegetation have been held for the last 30 years: mammalogists are convinced that vegetation had a complex structure at high latitudes ($>43^\circ\text{N}$), while palynologists working on lakes are convinced that steppes extended up to low latitudes, such as the northern Mediterranean realm ($<43^\circ\text{N}$). One way to solve this debate is to carry out pollen analyses on well-developed terrigenous marine sediments, such as was tested on the Gulf of Lions. Several cores retrieved from the shelf allowed to precise the history of trees in southern France during the last 50 ky. The data suggest (in accordance with mammal and bird records) the presence of a refugium of spruce, fir and deciduous oak in southern France up to the Younger Dryas. To conclude, palynology applied to marine terrigenous sediments is certainly the only way to provide the information lacking on vegetation dynamics during glacials.

PALYNOLOGY, WESTERN EUROPE, MEDITERRANEAN SEA, UPPER QUATERNARY

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The fire, humans and climate nexus in the Sydney Basin, Australia

Manu Black, Scott Mooney

This study presents three Holocene paleoecological sequences from the Sydney Basin, Australia with the aim of untangling any interrelationships between fire, climate and humans. Three contiguous charcoal curves, dating back to ~ 6.2 ka, ~ 14.2 ka and ~ 20 ka from Mellong Swamp, Gooches Crater and Lake Baraba, respectively, were compared to previous archeological and paleoclimatic research, and other analyses. The fire histories of Gooches Crater and Mellong Swamp displayed a positive correlation. There was variable charcoal during the late glacial-Holocene transition and less charcoal between ~ 9000 and 6000 yr BP at Gooches Crater. There was a relatively abrupt increase in charcoal at 5500 yr BP at both sites, after which charcoal then remained mainly high and variable. The dominant control on fire at Gooches Crater and Mellong Swamp during the Holocene appears to be climate, with periods of climatic variability and the strengthening of 'modern' El Niño events, associated with higher levels of fire activity. Coeval changes in paleoclimatic sequences elsewhere and palynology at the sites support a climatic explanation for the mid-Holocene fluctuations in charcoal or that Aboriginal people used fire within a climatic framework. Palynology from Lake Baraba provided a record of vegetational response to climate change associated with the Last Glacial Maximum and subsequent climatic amelioration. The Lake Baraba fire history was significantly different to the other sites, showing less of a relationship to changes in climate, and hence Aboriginal use of fire may have been a more important control at this site.

FIRE HISTORY, HOLOCENE, CHARCOAL, CLIMATE, ABORIGINAL

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Temperature variability of the past 2,000 years reconstructed using ^{18}O of stalagmites from northern Italy

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Multi-proxy studies of two northern Italian stalagmites provide comparable decadal temperature changes for the past 2,000 years: speleothem oxygen isotopes show positive linear relationships with reconstructed

mean annual temperatures from the Alps and for the northern hemisphere. A late-glacial and Holocene stalagmite SV1 from Trieste karst is composed of columnar calcite and fed by a continuous drip. The age model, based on 18 MC-ICPMS U-Th ages, suggests low axial growth rate (10-15 $\mu\text{m}/\text{year}$) during the last 2,000 years, which yields a mean resolution of 25 years for the stable isotopes. SV1 temperature reconstruction shows multi-centennial variability with temperatures similar to today during medieval times (AD 800-900 and AD 1100-1350) and around AD 0. Estimated mean decadal temperatures were 1.2°C cooler relative to today during the Little Ice Age (LIA) between AD 1550 and 1850. Negative temperature anomalies broadly correspond to minima of solar irradiance. Alpine stalagmite GZ1 shows dendritic fabric, resulting from high drip-rate variability. Eleven MC-ICPMS U-Th ages allow us to detect several hiatuses in the past 5,000 years. For the last 1,000 years, the mean axial growth rate was 200 $\mu\text{m}/\text{year}$, which yields a 10-year resolution for stable isotopes. GZ1 temperature reconstruction displays a remarkable similarity with reconstructed mean annual temperatures for the past 500 years in the Alp, although the ^{18}O minima are not recorded during the LIA but between AD 1150 and 1300. This is possibly related to the rainfall signature (amount effect) that enhanced the ^{18}O depletion during the first half of the second millennium.

SPELEOTHEMS, TEMPERATURE, OXYGEN ISOTOPES, GROWTH RATE, ITALY

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Holocene temperature of Europe from pollen data: Gradients and forcing

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Large-scale patterns of climatic change during the Holocene in Europe have been reconstructed using pollen-derived paleoclimatic data. Paleo-temperature reconstructions were made at over 500 sites in Europe, then assimilated onto a regular spatial grid and a regular time step for the Holocene period (12 ka BP to present). Area-averages were then calculated to obtain regional time series of climate change. Whilst average temperatures for the European continent are generally stable over the last 8,000 years, evidence from southern Europe suggests widespread low latitude cooling during the mid-Holocene 'climate optimum' observed

in the north. By comparing the time series obtained for the north and south of Europe, a reconstruction can be made of the latitudinal temperature gradient across the continent—an important measure of energy flux between the equator and pole. Past changes appear driven by the latitudinal insolation gradient (LIG) across this region, except in the early Holocene where the gradient is strengthened by residual ice cover. The weakening of the LIG in the mid-Holocene is not seen in GCM output run under 6 ka BP boundary conditions, suggesting an overreliance on high-latitude insolation. The LIG is influenced by obliquity in summer, and, due to the polar night, by precession in winter. Long-term changes in the annual LIG include both obliquity and precession cycles found in the glacial-interglacial record, and the influence of this on the distribution of temperatures may help to answer certain existing criticisms of Milankovitch theory.

HOLOCENE, TEMPERATURE GRADIENT, ORBITAL FORCING

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A 4,500-year record of aridity cycles on the Northern Great Plains, USA

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High-resolution analyses of a late-Holocene core from Kettle Lake, North Dakota, reveal coeval fluctuations in loss-on-ignition carbonate content, percentage grass pollen and charcoal flux. These oscillations are indicative of climate-fuel-fire cycles that have prevailed on the Northern Great Plains (NGP) for most of the late Holocene. High charcoal flux occurred during past moist intervals when grass cover was extensive and fuel loads high, whereas reduced charcoal flux characterized the intervening droughts when grass cover, and hence fuel loads, decreased. This illustrates that fire is not a universal feature of the NGP through time but rather oscillates with climate. Spectral and wavelet analyses reveal that the cycles have a periodicity of ~160 years, though secular trends in the cycles are difficult to identify for the entire Holocene, since the periodicity in the early Holocene ranged between 80-160 years. Even though the cycles are evident for most of the last 4,500 years, their occasional muting adds further to the overall climatic complexity of the plains. These findings clearly show that the continental interior of North America has experienced short-term climatic cycles accompanied by a marked landscape response for several millennia, regularly alternating between dual landscape modes. The presence of similar aridity cycles at other sites in the NGP and western North America suggest some degree of regional coherence

to climatic forcing. Accordingly, the effects of global warming from increasing greenhouse gases will be superimposed on this natural variability of drought.

ARIDITY CYCLES, CHARCOAL, FIRE, HOLOCENE, NORTHERN GREAT PLAINS

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ENSO effects in the North Atlantic-European sector—a paleo-perspective

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El Niño/Southern Oscillation (ENSO) is the most prominent mode of climate variability and affects atmospheric circulation over large regions of the globe. Recent studies suggest an effect also in the North Atlantic-European sector. However, the relation seems to be modulated by other factors as well. Here, we analyze the relation between ENSO and climate in the North Atlantic European sector based on empirical climate reconstructions for the past 250 years. Different coral-, tree-ring- and documentary-based reconstructions of ENSO indices are compared to reconstructed fields of near-surface air temperature, sea level pressure, and precipitation for Europe. The latter are each based on an independent set of predictors, including early instrumental, documentary and natural proxy data. In addition, reconstructed fields of 500 hPa geopotential height over the North Atlantic-European area are used. We discuss the linearity, seasonality, and stationarity of the teleconnection, as well as its modulation by other factors such as strong tropical volcanic eruptions, climate in the tropical Atlantic and the North Pacific region.

EL NIÑO, NORTH ATLANTIC, TELECONNECTIONS, RECONSTRUCTIONS

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Fluctuations of the NE monsoon over the SE Arabian Sea during the late Quaternary

Manjunatha Busnur, Shankar Rajasekharaiah

The Arabian Sea is one of the high-productivity seas in the world ocean because of the prevalence of the SW and NE monsoons. The former was weaker, while the latter stronger during glacial periods. A number of studies of the SE Arabian Sea indicate that paleoproductivity indicators like organic carbon did not change significantly in the glacial sequences. Here, an attempt has been made to understand the fluctuations of the NE monsoon during the late Quaternary, on the basis of geochemical and isotopic data of sediment cores. Trace elements such as Fe, Zn and to some extent Ni, and their Al-normalized concentrations show considerable down-core variations, with peaks around 22 kyr, 13 kyr and 11 kyr, with minor peaks at 7 kyr and 5 kyr. These peaks may be interpreted to be due to the dominance of the NE monsoon. However, many of them are antipathetically related to the weak phases of the SW monsoon recorded in the sediments of the NW Arabian Sea and, to some extent, the Central Indian Ocean. Therefore, it can be concluded that the intensity of the NE monsoon varied during the glacial period with episodes of strong northeasterly winds blowing over the eastern Arabian Sea, inducing pulses of high primary productivity. The main source of nutrients for primary productivity could be traced to the entrainment subsurface water as a result of the atmospheric forcing on the sea surface.

MONSOON, PALEOPRODUCTIVITY, TRACE METALS, ARABIAN SEA, INDIA

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Amazonian mangrove dynamics during the last millennium: The relative sea-level and the Little Ice Age

Marcelo Cancela Lisboa Cohen, Rubén Lara, Hermann Behling

The integration of stratigraphic and palynological data with radiocarbon dating has allowed the identification of two periods characterized by low inundation frequency during the last 1,000 years in the mangroves of the Bragança Peninsula in North Brazil. The first event extended over a period of 380 years and took place between AD 1130 and 1510. The second began about AD 1560 and probably finished at the end of the 19th century. These two events are temporally correlated with the so-called "Little Ice Age", and may reflect a sea-level regression and/or drier conditions with less rainfall. Our study also indicates that mangroves on the Bragança Peninsula have been migrating to higher

elevation zones during the last decades, suggesting a relative sea-level rise. This increase can be associated with the global tendency towards a eustatic sea-level rise, due to the increase in temperature and glacier melting around the world during the last 150 years.

AMAZON REGION, LATE HOLOCENE, LITTLE ICE AGE, MANGROVES, SEA-LEVEL

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Modeling vegetation shifts over the Sayan Mountains (Siberia) in changing climates from the past to the future

Nadja Chebakova, Elena Parfenova

In the absence of sufficient fossil pollen data across diverse mountain habitats, reconstructions of boundaries between vegetation types during both past and future periods can be carried out using modeling. A bioclimatic model was developed for the Sayan Mountains, Siberia (50-56°N and 89-96°E) that predicted a vegetation type: tundra, dark-needled (*Pinus sibirica*, *Abies sibirica*) taiga, light-needled (*Larix sibirica*, *Pinus sylvestris*) taiga and subtaiga, forest-steppe, and steppe from two climatic indices characterizing heat and water supplies. The model was coupled with the past, current, and future climates to predict mountain vegetation shifts from the mid-Holocene to the near future. Three climate change scenarios were applied to current climate to calculate the past and future climates for: 1. Mid-Holocene, 5500 BP (+2°C summer temperature and +10% annual precipitation; Borzenkova and Zubakov, 1995); 2. Subboreal, 3500 BP (-1.5°C and +15%, respectively; Zubareva, 1987); 3. Future climate by 2090 (+4°C and +15%, respectively). Under current climate, the tundra area is predicted to be large, as it was during the Subboreal, but larger than for the mid-Holocene and future warmed climates. In the mid-Holocene and Subboreal, characterized by moister climates, the forested area with predominantly water-demanding, dark-needled tree species was larger than that is today and will be in the future. The steppe area has increased since the mid-Holocene and is predicted to expand even more under a warmer and drier climate in the near 50-100 years.

VEGETATION, SIBERIA, CLIMATE CHANGE, HOLOCENE, FUTURE

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Holocene environmental change inferred from high-resolution pollen records of inland lake deposits in arid China

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A high-resolution pollen record from terminal lake sediments in the Shiyang River drainage on the margin of the modern summer monsoon was used to reconstruct vegetation and climate history during the Holocene. Forest trees, including *Sabina*, *Picea* and *Pinus*, dominated the pollen assemblages in the early Holocene (11.6-7.1 cal ka), while in the mid-Holocene (7.1-3.8 cal ka) desert and steppe shrubs and herbs, including *Nitraria*, *Poaceae*, *Compositae* and *Artemisia*, were dominant. The late Holocene (3.8-0 cal ka) was again alternatively dominated by *Pinus* and *Sabina* and desert-steppe vegetation. The early Holocene forest expansion and the highest river transport of tree pollen correspond with maximum precipitation during the East Asia summer monsoon maximum. The chronology of this event in our record from arid China is different from that for East China records, where the Holocene Optimum appeared in the middle Holocene. This difference indicates that the summer monsoon evolution in the Holocene was complex. The pollen record of the Shiyang River drainage has the periodicity of millennial- and century-scales, which appear to be pervasive and persistent throughout both the wet and dry periods of the Holocene. The seven principle arid events recorded by pollen in the region have global significance. Our results imply the continental interior was sensitive to changing moisture conditions and responsive to climatic events in the Holocene.

ARID INLAND CHINA, POLLEN ASSEMBLAGES, HOLOCENE CLIMATIC OPTIMUM, CLIMATE EVENTS, MILLENNIAL AND CENTURIAL VARIATION

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Variations of the Last Glacial Warm Pool: SST contrasts between the open Western Pacific and South China Sea

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High-resolution paleoceanographic records from the southern South China Sea (SCS) and the tropical open western Pacific reveal multi-centennial to millennial

scale variations of the Western Pacific Warm Pool (WPWP) over the last 40 ka. During the last glacial maximum (LGM), in MIS 2, planktonic *Globigerinoides sacculifer* $\delta^{18}\text{O}$ in core NS93-5 from the southern SCS and in core WP92-5 from the central WPWP registered a similar average value of about -1.5‰. However, the average $\delta^{18}\text{O}$ value was about 0.5‰ more negative in the SCS than in the central WPWP, as was their difference before and after the LGM in the later part of MIS 3 and early portion of MIS 1. These results indicate weaker monsoonal and fluvial effects on the southern SCS during the last glacial than during pleniglacial and postglacial periods, due to different oceanic circulation modes and regional topography. The calculated seasonal temperature differences of summer and winter sea surface temperatures (SST) between the open WPWP and the southern SCS were up to 3-4.5°C during the LGM but only slightly over 3°C in the southern SCS, and less than 2°C in the open WPWP during other periods. From about 29 to 25 ka, the MIS 2/3 transition was marked by a sudden SST increase in the southern SCS but a decrease in the open WPWP. Over this 4 kyr period, the average annual SST appeared to be only 28°C in the central WPWP but more than 28°C in the southern SCS, indicating a shift of the central WPWP toward the far west during that time. Furthermore, our results imply a period of nearly 6 kyr from 22.5 ka to 16.5 ka without an apparent warm pool of 28°C in the western Pacific.

WESTERN PACIFIC WARM POOL, SOUTH CHINA SEA, SEA SURFACE TEMPERATURE, LAST GLACIAL MAXIMUM, PALEOCEANOGRAPHY

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A preliminary reconstruction of temperature change over the past 1,000 years in China

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Twenty seven tree-ring chronologies from 7 individual sites in western and northeastern China, with proven quality and capable of indicating seasonal temperature variation at regional scale, were collected and used to reconstruct regional annual mean temperature series. Combined with the winter-half-year temperature series in eastern China, as reconstructed by Ge et al. (2003) using historical documents, area-averaged annual

mean temperature anomalies with time resolutions of 10-30 years over the past 1,000 years for the whole of China were also reconstructed. Wavelet analysis was made for the regional series, which indicates a significant centennial cycle, though the periodic signs tend to be weaker after AD 1500. Variability and amplitudes of cold-warm changes in China over the past 1,000 years are discussed. Choosing AD 1951-1980 as the climate reference period, the annual mean temperature of China was generally warmer from AD 1000 to 1310, with a relatively cool episode in the 13th century, and was significantly colder from AD 1310 to 1910, with minimum anomalies occurring in the 15th, 17th and 19th centuries. The modern warm period beginning from the end of the 19th century looks unusual in terms of the 1,000-year variation of annual mean temperature but it is not significantly warmer than the earlier warm period or Medieval Warm Period (MWP). Some differences between the series of western and eastern China have been detected and there seems to be no significant warming during the MWP in the western temperature series. We also compare the present temperature series with those of other researchers.

CLIMATE CHANGE, TEMPERATURE, MEDIEVAL WARM PERIOD, MODERN WARM PERIOD, CHINA

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An 18,000-year multiproxy lacustrine record of climate variability in south-central Chile (40°S): Lago Puyehue, Chilean Lake District

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An 11-m-long sediment core was collected in Lago Puyehue (40°S, Lake District, Chile). The coring site was selected on the basis of a seismic-stratigraphic analysis that highlighted it as an area of relatively condensed, continuous and undisturbed sedimentation in this otherwise highly dynamic post-glacial lake. The 11-m core extends back to 17,915 cal yr BP. An age-depth model was established by 9 AMS ^{14}C dates, constrained by ^{210}Pb , ^{237}Cs , ^{241}Am measurements, by the identification of event-deposits related to earthquakes and/or volcanic eruptions, and by varve-counting for the past 600 years. The core was submitted to multi-proxy analysis, including sedimentology, mineralogy, grain-size, major geochemistry and organic geochemistry (C/N ratio, $\delta^{13}\text{C}$), loss-on-ignition, magnetic susceptibility, diatom analysis and palynology. Along-core variations

in sediment composition reveal that since the Last Glacial Maximum (LGM), the area of Lago Puyehue was characterized by a series of rapid climate fluctuations superimposed on a long-term warming trend. These rapid climate changes are: (1) An abrupt warming at the end of the LGM at 17,300 cal yr BP, (2) A short, relatively cold interval between 13,100-12,300 cal yr BP, (3) A second abrupt warming, possibly with increased precipitation, at about 12,300 cal yr BP, and (4) An increase in climate variability in the late Holocene at 5000-6000 cal yr BP. Spectral analysis of varve-thickness variations over the past 600 years reveal periods that display sub-decadal periodicities similar to those associated with the El Niño Southern Oscillation and the Pacific Decadal Oscillation.

CHILE, LAKE, DEGLACIATION, HUELMO-MASCARDI
COLD REVERSAL, HOLOCENE

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Dynamics of abrupt climatic change over climate regions in Nigeria

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The paleoclimate record of past environmental change clearly shows that the instrumental record contains only a subset of possible climate system behavior. This is highlighted, for example, by paleoclimatic evidence that the climate system repeatedly switches, in a matter of years to decades, between significantly

different climate modes. Climate change is reviewed over climate regions in Nigeria using 38 years (1961-2009) of climatological data of air temperature (0600-1400 utc), minimum and maximum temperature, and relative humidity (0900 utc) for 45 stations. The climatic regions are Sahel Savannah, Sudan Savannah, Guinea Savannah, tropical rainforest and mangrove swamp. The results generally show a temperature increase over the decades and a decrease in relative humidity. In conclusion, the significance of past abrupt climate changes is heightened by the fact that they cannot be studied using instrumental data, and because their origins are poorly understood. Careful work is needed to map out the spatial-temporal patterns of change associated with past abrupt events that occurred in the climatic regions in Nigeria, to determine their causes, and also to determine if they are predictable.

NIGERIA, ABRUPT CLIMATE CHANGE, CLIMATE REGIONS

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Karstic systems and the preservation of paleoenvironmental signals by speleothems

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Speleothems are primarily studied in order to generate archives of climatic change, but the way in which the weather, the seasons and longer-term climatic fluctuations become encoded is dependent on environmental filters, which can be modeled formally using time-series statistics. It is useful to distinguish five sources of variation: atmospheric, vegetation/soil, karstic aquifer, primary speleothem crystal growth and secondary alteration. The direct role of climate diminishes progressively through these five factors. Here, particular attention is paid to high-resolution geochemical variation, including a comparison of conventional, laser-ablation and ion microprobe isotope analysis, and the light that they shed on different potential causes of decadal-scale isotopic variation. A variety of trace element patterns occur, with a strong seasonality reflecting variation in cave ventilation and/or dryness. A particularly robust and simple trace element pattern from the Clamouse Cave in southern France marks the expression of an arid phase 1200-1100 BP that may have had a widespread distribution.

SPELEOTHEMS, KARST, ARIDITY, TIME SERIES, CHEMICAL ANALYSIS

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Impact of climate change on weed phenology

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The objectives of this study were to determine the phenological characteristics of fourteen durum wheat weeds, to relate their growth to the accumulation of heat units and to study the effect of climatic changes on their growth cycle by comparing our results with old data. Growth stages of major weeds in cereals of the Sétif high plains (North-East, Algeria) were recorded for three years. The phenological stages of these species were recorded as: first leaf, vegetative development, flowering, maturity of seed, and senescence. The phenology of 14 annual weeds was determined, and two groups were identified: autumn-winter species and spring species. Much variation exists in phenology among and within groupings of these species. Variability in phenology of these weeds was dependent on temperature patterns of the year. The results show that number of days between emergence and flowering is influenced by temperature and daylength. The flowering dates for these species could be correctly predicted by using the summation of degree-days. The comparison between these results and old phenological data shows that speed of development is larger and vegetative cycles shorter. Increased effort needs to be put into phenological research. Understanding the many relationships involved will improve interpretation of phenological events for management decisions in agriculture. Studies of this nature will make it possible to predict weed growth rates and to determine the appropriate timing for the application of foliar herbicides in order to optimize their use and avoid secondary effects of herbicide treatment, such as soil and water pollution.

CLIMATE, DEGREE-DAYS, WEEDS, PHENOLOGY, SÉTIF

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A 1,000-year multiproxy Holocene climate record for northwest Scotland

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The relationship between ^{18}O in precipitation, percolation waters and contemporary calcite at Uamh an Tartair cave system, Northwest Scotland is presented. This site is located on the North Atlantic Seaboard in a climatically sensitive area where precipitation relates to the NAO and temperature to ocean circulation via the North Atlantic drift, and for which late Holocene annual climate reconstructions have been published from luminescent-laminated stalagmites. High-resolution $^{18}\text{O}/^{16}\text{O}$ ratios have been measured within these Holocene stalagmites, however interpretation of this data requires thorough monitoring of the cave system. Observations showed that ^{18}O in precipitation varied seasonally with a 7.1‰ range, a negative linear relationship with rainfall amount, and no correlation with temperature. Cave percolation waters are significantly attenuated and show little variation during the monitoring period. The annual mean ^{18}O of the percolation waters is the same as the weighted annual mean of the precipitation. This, together with drip water hydrological and geochemical data, indicates that percolation waters are well mixed and dominated by stored water. Values for ^{18}O of contemporary calcite are predicted using measured values of cave temperature and ^{18}O of the drip waters. These predicted values compare very well with actual contemporary calcite measurements and suggest that the cave deposits are forming in isotopic equilibrium and that kinetic effects are negligible. Modern calibration data, together with high-resolution stable isotope and annual lamina width data provides the basis for a multiproxy Holocene climate record for NW Scotland.

HOLOCENE, STALAGMITE, STABLE ISOTOPE,
PALEOCLIMATE

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Reconstruction of AD 1736-1911 high-resolution precipitation over China using historical archives of the Qing Dynasty

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Chinese historical documents, containing abundant descriptions of weather conditions, are an important data source for reconstructing the climate of the past hundreds or even thousands years. Here, the Yu-Xue-Fen-Cun records from the reign of Emperor Momos-to during the Qing Dynasty are used to reconstruct high-resolution, quantitative precipitation data. This is possible because these records contain detailed dates and rain infiltration or snow depth for every precipitation event during AD 1736-1911, and cover 273 administrative sites in 18 provinces. To discuss the methodology of reconstruction, a case at Shijiazhuang is presented. The reconstruction of total precipitation involves the reconstruction of quantitative rainfall based on the soil penetration depth, and the reconstruction of quantitative snowfall based on the snow depth. To convert the soil penetration depth into a quantitative rainfall amount, a conversion function is established, which is affected by soil characteristics, initial moisture content, rainfall duration and intensity, using a field measurement program following the same measurement method documented in the historical records. A regression equation between the snow depth and quantitative snowfall derived from instrumental meteorological observation data is used for snowfall reconstruction. Results show that summer and winter precipitation during AD 1736-1911 were generally higher than the AD 1961-1990 means, with much larger fluctuations in summer and a decreasing precipitation trend for a long period of AD 1825-1875 in winter. Moreover, this long-term, high-resolution, quantitative data reconstruction enables us to speculate on the circulation statistic characteristics for the extreme drought and flood events during the pre-instrumental period, which will be very helpful to historical climate regional model simulation.

RECONSTRUCTION, HIGH RESOLUTION, PRECIPITATION, CHINA, HISTORICAL ARCHIVES

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Multiproxy approaches to El Niño-Southern Oscillation (ENSO) reconstruction: Integrating evidence from tree-ring, coral, ice-core and documentary archives, AD 1525-2002

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ENSO (El Niño-Southern Oscillation) is the largest source of inter-annual variability operating in the Earth's climate system. Nevertheless, no consensus exists within the scientific community as to which index best characterizes events. To address this, the Coupled ENSO Index (CEI) was devised to identify synchronous oceanic (Niño 3.4 region SSTs) and atmospheric (Southern Oscillation Index) anomalies for the instrumental period (1871-2003). The CEI is a composite, instrumental index of ENSO evolution for the calibration of high-resolution proxy records. This allowed seasonal and teleconnection signatures of individual events to be systematically resolved using a number of proxies responding to different aspects of ENSO. To demonstrate the implications of using a sole ENSO index for proxy calibration, approx. 500 years of a continuous 3,722-year tree-ring record from New Zealand Kauri are introduced. The Kauri record is now the longest tree-ring proxy of past ENSO available from the Western Pacific. Recently, modern Kauri chronologies were updated to assist refine transfer functions used to assess late 20th century ENSO from a multi-centennial perspective, from the currently "data sparse" southern hemisphere. To avoid making global inferences from single proxy analysis, regional signals were aggregated into a network of high-resolution records (tree-ring, coral, ice and documentary), revealing large-scale trends in the frequency, magnitude and duration of pre-instrumental ENSO. Results of discrete event and principal component regression analyses are presented as complimentary techniques for the evaluation of recent extreme events, signifying a considerable contribution to global efforts aimed at understanding ENSO dynamics.

ENSO, MULTIPROXY, PALEOCLIMATE RECONSTRUCTION, EL NIÑO, DENDROCLIMATOLOGY

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Mid-Holocene North Atlantic Oscillation: a PMIP2 model intercomparison

Rupert Gladstone, Paul Valdes

The Palaeoclimate Modelling Intercomparison Project Phase 2 (PMIP2) includes coupled ocean-atmosphere and coupled ocean-atmosphere-vegetation general circulation model (OAGCM and OAVGCM) simulations of the mid-Holocene climate from many modeling groups across the globe. Robust features in the changes of structure of the North Atlantic Oscillation (NAO) are currently being studied using principal component analysis on the modeled sea-level pressure fields. As a test for how well the leading empirical orthogonal function (EOF) represents the NAO, its associated principal component is correlated to the NAO index. The time and frequency domain of both the leading principal component and the NAO index will be used in studying variability of the mid-Holocene NAO. The study will aim to identify features of climate associated with changes in the NAO for which proxies are available in the mid-Holocene.

NORTH ATLANTIC OSCILLATION, PRINCIPAL COMPONENT ANALYSIS, PMIP2, HOLOCENE

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Holocene oceanography and climate in the southern Gulf of California

Oscar E. Gonzalez-Yajimovich, Robert G. Douglas, Donn S. Gorsline

Alfonso Basin, on the western side of the Gulf of California, and Pescadero Basin, on the center slope of the east side, have sills or shoreward slopes in the Oxygen Minimum Zone and preserve laminations whose physical and geochemical characteristics yield information on climatic and oceanographic changes. Here, primary productivity and sedimentation can be considered as an imperfect proxy of climate. Cores were sampled at 1-cm intervals to produce a record of organic carbon, carbonate, opal and terrigenous content, and contained laminated, hemipelagic mud, accumulating at 25-50 cm/kyr. Major changes in sedimentation began at ca. 7200 yr BP, with major shifts occurring at 4200 and 3000 yr BP, and smaller changes at 1500, 950, and 400 yr BP in both basins. A stepwise decrease in mass accumulation rates can be correlated to northern hemisphere summer insolation, and suggests stronger NW winds and decreasing rains. Biogenic records indicate a drop in productivity, and terrigenous mud records a shift from wetter to dryer conditions. At 400 yr BP, a recovery suggests a return to wetter less windy conditions. Three general climatic periods are recognized. Spectral analysis shows a 1-2

kyr climate rhythm in the Gulf and the data suggest that it is mediated by the migration of the Intertropical Convergence Zone (ITCZ) due to orbital precession. The records are marked by strong climate-ocean variability cycles with two modes: 210 years (throughout the record) and 800 years (after 3000 yr BP) that appear related to latitudinal shifts of the ITCZ, produced by solar cycles.

GULF OF CALIFORNIA, HOLOCENE, ALFONSO BASIN, EASTERN PESCADERO BASIN, CLIMATE VARIABILITY

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Carbon and oxygen isotope composition of land snail shells from Chinese Loess Plateau and their environmental significance

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Fossil land snail shells are plentiful in the wind blown Chinese loess sequences. Their carbon and oxygen isotope composition have the potential to indicate past changes in paleoclimate and vegetation. However, no successful isotopic work on snail shells from the loess sequence has been presented for this purpose, since the significance of snail shell carbonate isotopes for climate and ecology have not been fully understood. Here, we show our recent work on isotopic composition of live and fossil land snail shell carbonate and their relation to snail diet and climatic environments on the Loess Plateau. The data show that: 1) live snail aragonite shells from semiarid areas are rich in both ^{13}C and ^{18}O , relative to shells from semi-humid regions in the Loess Plateau 2) shell $\delta^{13}\text{C}$ values are strongly correlated with mean annual precipitation (MAP), while $\delta^{18}\text{O}$ values are more closely correlated to summer precipitation than to MAP, and 3) fossil shell carbon and oxygen isotope records from the last glacial loess deposit in the southern margin of the Loess Plateau are well correlated with other records of changes in seasonal precipitation or humidity. These results support the theory that the isotopic composition of land snail shell carbon depends on the photosynthetic type of the plant diet, controlled by the seasonal climate when the snail is active. However, land snails favor C3 photosynthetic vegetation as their food source, although there are observable amounts of C4 plants where they live. Since land snails are active only in the warm and wet season, our results suggest that the composition of both carbon and oxygen isotopes in the snail shell carbonate would be proxies to indicate seasonal precipitation changes in the past.

STABLE ISOTOPE, LAND SNAIL, SHELL CARBONATE

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Mid-Holocene changes in variability in reconstructed and simulated temperatures

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Analysis of climate change in the mid-Holocene has been largely restricted to examining changes in anomalies in time or in space. We present some first results looking at quantified changes in the variability of temperature parameters at 6 ka BP, using a set of proxy records and simulations from a coupled ocean-atmosphere model. Variability change was studied in proxy data at a global scale by assembling a set of high-resolution sequences, based on a variety of climate proxies with an approx. sampling frequency of 20-50 years. The change in variability was represented by the change in standard deviation. Results show a general reduction of variability in the southern hemisphere, but a more mixed pattern in the northern hemisphere. The NH spatial heterogeneity was further investigated at the regional scale, by combining sets of lower resolution pollen-based temperature reconstructions into pseudo 'high' resolution sequences for the western European continent with approx. the same sampling frequency. These results are spatially coherent and show a general agreement with changes in high-resolution sequences. A further comparison has been made with output from the IPSL GCM run under 6 ka BP boundary conditions, filtered to give an equivalent temporal resolution. The agreement between the observed and simulated variability changes is generally good, although some regional differences are apparent. The combination of these different approaches offers a useful tool for studying and comparing changes in past climate variability and improving our understanding of the response of climate proxies to these changes.

HOLOCENE, CLIMATE VARIABILITY, MODEL-DATA

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Pollen-based Holocene paleotemperature reconstruction from southern Finland

Maija Heikkilä, Heikki Seppä

The ecotone between the boreo-nemoral (hemiboreal) and the southern boreal vegetation zones constitutes the northern distributional limit of a number of thermophilous tree species in northern Europe and is, to a large extent, controlled by climatic conditions. This study presents a quantitative annual mean temperature reconstruction from a high-resolution pollen stratigraphy in southern boreal Finland, using a pollen-climate calibration model with a cross-validated prediction error of 0.91°C. Our model reconstructs low but steadily rising annual mean temperature from 10,700 to 9000 cal yr BP. At 8000-4500 cal yr BP reconstructed annual mean temperature reaches a period of highest values (Holocene thermal maximum, ca. 2.0-1.5°C higher than at present. From 4500 cal yr BP to the present-day, reconstructed annual mean temperature gradually decreases by ca. 1.5°C. Comparison of present results with paleotemperature records from the Greenland ice cores, notably with the NorthGRIP $\delta^{18}\text{O}$ record, shows marked similarities, suggesting parallel large-scale Holocene temperature trends between the North Atlantic and North European regions. Millennial-scale temperature trends depicted in these records cannot be directly interpreted by the solar radiation changes. The associated feedback effects and to the role of atmospheric circulation changes must play an important role, producing variation not only in temperature but also in moisture-related variables in North European climates. The verification of the nature of Holocene climate fluctuations in the boreal-temperate Europe requires replicate high-resolution climate reconstructions.

POLLEN, PALEOTEMPERATURE, BOREO-NEMORAL ECOTONE, FINLAND, HOLOCENE

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Coral growth in the southern Gulf of Mexico in the context of global warming

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Annual extension rates (AER) for the 1848-2002 period of the coral *Montastraea franksi* were determined from four cores collected at Southern Gulf of Mexico (SGM). Mean AER was 10.8 mm/year, with no significant differences in intra-colony or inter-colony values. Analyzing a single master times series of growth, five time trends were observed. The final stage from 1990 that extends into present times showed a decreasing AER trend. It is worth noting that surface air temperature (SAT) for the northern hemisphere (NH) and SST for

the collection site show the same pattern through time as the AER record. Also, two significant frequency bands of periodical growth variation were identified by power spectral analysis of AER at 3.0 and 2.4 years, which probably are related to the modes of climate variability that impose periodical variation with the same frequencies on SST in the tropical Atlantic, like ENSO and the quasi-biennial mode of variability of the tropical Atlantic, respectively. Therefore, in the long-term, temperature is the main forcing environmental factor on AER. Of great concern is the fact that the NHSAT has been increasing during the 20th century due to phenomenon of global warming to its highest records in the last millennium. Unfortunately, corals from the SGM show that NHSAT positive anomalies (>0.3 °C) recorded since 1990 have affected them, lowering their AER by 1 mm/year in the same period. If global warming follows its increasing trend in the next future, coral and reef growth may decrease to critical levels.

CORAL, GROWTH, GULF OF MEXICO, GLOBAL WARMING

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Annual, interannual and interdecadal variability of Asia monsoon during the Holocene

Chaoyong Hu, Gideon M. Henderson

~150 years historical records of all Indian summer rainfall show Asian monsoon oscillates in annual, interannual and interdecadal rhythm. However, high frequency variability of monsoon before that time remains unclear. Here, we present a seasonal resolution Mg/Ca record retrieved from a 9500-year stalagmite from the central Yangtze valley in China, to understand how monsoon varied in amplitude and frequency in the Holocene. The correlation between Mg/Ca in the stalagmite and rainfall is negative, less rainfall during the weak monsoon producing higher Mg/Ca signal in stalagmite. Data shows monsoon strengthen in the early Holocene, reach maximum at 5-7 ka BP, and weaken after 5 ka BP. Asian monsoon oscillates in the period of 1, 11, 23, 88 years, implying solar forcing of the monsoon.

STALAGMITE, ASIAN MONSOON, HOLOCENE, SEASONAL RECORD, Mg/Ca

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Modeling the middle Pliocene climate with a global atmospheric general circulation model

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A new climate simulation for the middle Pliocene (ca. 3 Ma BP) is performed by a global grid-point atmospheric general circulation model developed at the Institute of Atmospheric Physics (IAP AGCM) with boundary conditions provided by the U.S. Geological Survey's Pliocene Interpretations and Synoptic Mapping (PRISM) group. It follows that warmer and slightly wetter conditions dominated at the middle Pliocene with a globally annual mean surface temperature increase of 2.6°C, and an increase in precipitation of 4.0% relative to today. At the middle Pliocene, globally annual terrestrial warming was 1.86°C, with stronger warming towards high latitudes. Annual precipitation enhanced notably at high latitudes, with the augment reaching 33.5% (32.5%) of the present value at 60-90°N (60-90°S). On the contrary, drier conditions were registered over most parts at 0-30°N, especially in much of East Asia and the northern tropical Pacific. In addition, both boreal summer and winter monsoon significantly decreased in East Asia at the middle Pliocene. It is indicated that the IAP AGCM simulation is generally consistent with the results from other atmospheric models and agrees well with available paleoclimatic reconstructions in East Asia. Additionally, it is further revealed that the PRISM warmer sea surface temperature and reduced sea ice extent are main factors determining the middle Pliocene climate. The simulated climatic responses arising from the PRISM reconstructed vegetation and continental ice sheet cannot be neglected on a regional scale at mid to high latitudes (like over Greenland and the Qinghai-Tibetan Plateau, and around the circum-Antarctic), but have little influence on global climate.

ATMOSPHERIC MODEL, MIDDLE PLIOCENE, CLIMATE SIMULATION

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Paleoenvironmental analyses of two mid-sized high arctic lakes: Crossing thresholds?

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The Arctic is well-recognized as a region sensitive to global climatic change. Indeed, many recent paleolimnological studies from both large lakes and

small ponds in arctic regions have shown dramatic changes in biological microfossils consistent with climatic warming over the past approx. 150 years. The types of changes are different, however, with lakes generally exhibiting an increase in planktonic species and ponds characterized by flora typical of greater periphytic habitat availability. What is less well-understood, however, is how environmental change might have affected the diatom communities of mid-sized arctic lakes. Relative to its latitude, the Lake Hazen basin region of northern Ellesmere Island, Arctic Canada, experiences anomalously warm summer conditions. It is possible that diatom communities from warm regions would have responded differently to environmental change than those in cooler areas; however, the types of responses are currently unknown. In particular, it is possible that these medium sized lakes may represent thresholds between the types of responses represented by lakes and ponds. Here, we assess the rate, magnitude and direction of diatom species assemblage changes from two mid-sized lakes (depths approx. 3 m and 4 m) located in this warm arctic oasis (81°50'N, 71°28'W). We address whether diatom assemblages indicate species changes through time in these mid-sized lakes, and if so, whether these species changes are similar to either those of large lakes or small ponds. In addition, we compare our diatom-based paleolimnological records to those from cooler regions.

ARCTIC, LAKE, PALEOLIMNOLOGY, DIATOMS, ENVIRONMENTAL CHANGE

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Sedimentological and isotopic characteristics of turbidites in the distal Bengal Fan

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Detailed investigations of two sediment gravity cores from the distal Bengal Fan indicate two distinct sedimentary units, the lower unit 2 and upper unit 1. The lower unit 2 sediments are olive black/grey with abundant silt, no biogenic constituents, low organic carbon (OC)/CaCO₃, and more quartz, mica, illite and chlorite. Uniform rock-magnetic properties, consistent ⁸⁷Sr/⁸⁶Sr and eNd values similar to that of the Ganges are typical of this unit. The upper unit 1 sediments are moderate brown/yellowish brown with an intermittent dark sediment layer. It is characterized by increased clay/OC/CaCO₃/biogenic constituents, enriched smectite and kaolinite, lower ⁸⁷Sr/⁸⁶Sr, more negative eNd and higher magnetic susceptibility. The unit 2 sediments

represent Pleistocene hemiturbidites, older than 13 ¹⁴C kyr BP with its source from the Northern Bay of Bengal (NBOB), derived from the Himalayas and transported by the Ganges-Brahmaputra (G-B) River system. Unit 1 sediments are calcareous-dominated pelagic sediments, started depositing since ~12 ¹⁴C kyr BP, with its clastic sediments derived from the Himalayas and SE Indian/Sri Lankan margins. The change in lithofacies from unit 2 to unit 1 suggests that the sediment deposition by turbidity current activity ceased in the distal Bengal Fan at ~12 ¹⁴C kyr BP, perhaps due to the rapid rise in sea level during the melt water pulse 1A and Holocene.

TURBIDITIES, PELAGIC SEDIMENTS, PROVENANCE, LATE QUATERNARY, DISTAL BENGAL FAN

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Carbon accumulation in the bog ecosystem determined by dendrochronological approach

Anastasia Knorre

Bog ecosystems occupy a significant part of Russia and play an important role in the turnover of major biogenic elements. We suggest a method of estimation of the annual rate of carbon deposition on a sphagnum column. This method combines theoretical and experimental approaches to the problem and has the following specific features: (1) it can be applied to a large number of bog ecosystems, and (2) it is based on peatland characteristics that can be measured relatively easily. The sphagnum column age was estimated using the dendrochronological method of determination of the absolute age of pine trees. The age of the trees used in this analysis ranged from 7 to 136 years. According to the results of our calculations, the value of moss production (NPP) is 120 g/m²/year. If, at the age of more than 120 years degradation is absent, the value of NEE is 50 g/m²/year. This estimate is consistent with the results of direct measurement of the rate of carbon accumulation in the bog studied in this work (49-52 g/m²/year).

DENDROCHRONOLOGY - ECOLOGY, GEOBOTANY

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Mollusk evidence for the origin of the late Miocene-Pliocene loess-soil deposits in the western Chinese Loess Plateau

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In the eastern Loess Plateau of northern China, the Quaternary loess-paleosol sequences are underlain extensively by the late Tertiary (Neogene) red clay deposits, called the Hipparion Red Clay Formation, which have great potential for the study of long-term monsoon changes and the uplift of the Tibetan Plateau. In the western Loess Plateau, however, an eolian deposit of late Miocene-Pliocene, approx. equivalent to the red clay deposit, has been reported recently. In this study, a new mollusk record from the Dongwan section, Qinan, has been presented to address the origin and post-depositional processes of the eolian deposits. Our results show that all identifiable mollusk species in the section are composed of terrestrial taxa such as Vallonia, Pupilla, Cathaica, Metodontia, Punctum, and Gastrocopta, almost all the same as those in the overlying Quaternary loess-paleosol sequences. Most of mollusk fossil individuals maintain at a living condition, showing an original population preserved. The higher similarity of mollusk composition and magnetic susceptibility values between the late Miocene-Pliocene eolian deposits and the overlying Quaternary loess-paleosol sequence shows the same origin in formation background, this supports the view that the late Miocene-Pliocene eolian sequence at Dongwan section is a typical loess-paleosol sequence as the same as the overlying Quaternary loess deposits, being a wind-blown origin. Compared to the Xifeng red clay sequence, a contemporaneous eolian deposit, the Qinan loess-paleosol sequence shows marked differences in mollusk composition, sedimentary feature and magnetic susceptibility values. The Qinan loess-paleosol sequence displays more similar features to the overlying Quaternary loess deposits, suggesting that distinct environmental difference existed at these two sites during the late Miocene-Pliocene epoch.

MOLLUSK FOSSILS, RED CLAY, LATE MIOCENE-PLIOCENE, ORIGIN

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Statistical characteristics of annual precipitation variation during the past 1000 years in Delingha, Qinghai Province, China

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Climate change has been an important issue in the present world. In order to study the statistical

characteristics of annual precipitation variation for the past 1000 years in Delingha, Qinghai Province, Northwest China, several statistical methods were applied in the reconstructed time series from seven chronologies built by tree ring samples collected in mountains along northeastern margin of Qaidam Basin. The quasi-200-year cycle was present during the whole time period (AD 1000-2001) of the series, especially in the period of AD 1200-1800, being more intense during AD 1440-1640. From the end of the 18th century, the quasi-120-year cycle was present and stronger in the next two centuries. The phases of these two dominant cycles were opposite in the 19th century, and tended to uniform in the 20th century. The central time period (AD 1920-1940) of the negative phase is in agreement with the lower water time period of AD 1922-1932 over the Yellow River basin. The abrupt changes of decade-century scales on the average value are present in seven time segments, which are AD 1100-1111, 1403-1449 and 1615-1661, with precipitation increasing, and AD 1321-1348, 1497-1557, 1728-1743 and 1885-1891, with precipitation decreasing. The abrupt changes of more than 200 years timescales on the variation amplitude shows that the amplitudes of lower frequencies changes increased during AD 1220-1580, in which the changes are more significant in the 15th century.

NORTHWEST CHINA, ANNUAL PRECIPITATION, CENTURY SCALE, PERIODICAL CLIMATE CHANGE, ABRUPT CLIMATE CHANGE

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A simulation of the early Holocene climate with a fully coupled atmosphere-ocean-vegetation model

Yan Liu, Sandy Harrison

A fully coupled atmosphere-ocean-vegetation (AOV) general circulation model was used to investigate the climate of the early-Holocene (~11,000 year BP). The main features of the early-Holocene climate were simulated, including enhanced continentality and seasonality, and an enhanced northern monsoon. The difference of surface temperature response during 11 ka was consistent with the large seasonal difference of orbital forcing. A global increase of precipitation was mainly related to the summer precipitation. The AOV

simulation of 11 ka demonstrated a strong synergism among climate subsystems.

EARLY HOLOCENE CLIMATE, NUMERICAL MODELING, ATMOSPHERE-OCEAN-VEGETATION, GENERAL CIRCULATION MODEL

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Carbon isotopic composition of live land snails from the Chinese Loess Plateau as an indicator of their diets

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The carbon isotopic composition of land snail aragonite shells has been used as an indicator of change in paleodietary plants. However, there is a debate about the origin of carbon in the snail shell carbonate. Here, we show our recent study on carbon isotopic composition of shell carbonate and organic body of live land snails from the Loess Plateau to argue the shell inorganic carbon origin. Several species of land snails were collected in semiarid and semi-humid regions from the northwest to the southeast Loess Plateau. Stable carbon isotopic composition has been measured on the aragonite shells and associated organic bodies of 27 snail samples respectively. Each of the samples consists of 10 adult snails from one species in a locale. The result shows that $\delta^{13}\text{C}$ values of both of the shells and the bodies have a broad range from -13.1‰ to -4.3‰ and from -26.5‰ to -18.0‰ respectively. The shell $\delta^{13}\text{C}_{\text{inorg}}$ value decreases with body $\delta^{13}\text{C}_{\text{org}}$ toward the southeast of the plateau. There is a close relationship between values of $\delta^{13}\text{C}_{\text{inorg}}$ and $\delta^{13}\text{C}_{\text{org}}$, which can be expressed as $\delta^{13}\text{C}_{\text{inorg}} = 1.02 \delta^{13}\text{C}_{\text{org}} + (14.4 \pm 0.8)\text{‰}$ ($r^2 = 0.927$, $n = 27$). This relationship supports strongly that carbon isotopic composition of the land snail shell carbonate depends on that of its diets because it has proved that the carbon isotopic composition of snail organic body is as same as that of its diet, and that the carbon in snail shell is from the metabolic CO_2 . However, the intercept of the equation is not constant. Differences ($\Delta\delta^{13}\text{C}$) between $\delta^{13}\text{C}_{\text{inorg}}$ and $\delta^{13}\text{C}_{\text{org}}$ values are in a range from 12.8‰ to 15.5‰ , indicating that carbon isotope fractionation between body liquid and the metabolic CO_2 must be partly with respect to the CO_2 diffusion.

LAND SNAILS, DIET, CARBON ISOTOPES, CHINESE LOESS PLATEAU

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Geochemical record for the historical penguin population in "Mochou" Lake sediments on the Larsemann Hills, East Antarctica

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An 85-cm-long sediment sequence from "Mochou" Lake on Mirror Peninsula in the Larsemann Hills, East Antarctica, was investigated for elemental geochemistry, biogeochemistry and strontium isotopic compositions in acid-insoluble and acid-soluble fractions. The geochemical characters of the elements in the bulk sediments show that Zn, Cu, F, S, P, and Se have relatively large coefficients of variation and display almost the same vertical distribution patterns, and the ratios of these elements with LOI have strong positive correlations with each other, indicating a common source, likely from penguin droppings. This observation is supported by the affinity of heavy metal pollution elements Hg, Cd, Ni, and As to these elements and the strontium isotopic compositions in the acid-insoluble and acid-soluble fractions of the sediments. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in the acid-insoluble fraction are between 0.750813 and 0.765720, characteristic of the bedrock. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in the acid-soluble fraction vary from 0.709291 to 0.711162, slightly higher than the ratio of modern-day seawater (0.70918). Furthermore, the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in the acid-soluble fraction are inversely correlated with the concentration of total amino acids, indicating that historical penguin populations may play the dominant role in providing nutrient supply into "Mochou" Lake. Based upon these results, we argue that the marine-derived Sr and nutrients are likely to be transported into the lake by penguin activity within the catchment area. Using geochemical signals in the radiocarbon-dated sediment core, we have reconstructed changes of historical penguin population in the catchment of "Mochou" Lake over the past 4000 years. A tentative comparison of historical penguin population and climatic changes in the Larsemann Hills suggests that the penguin populations seem to be linked to climate-related factors such as sea-ice coverage in the adjacent Prydz Bay and atmospheric temperature.

EAST ANTARCTICA, LAKE SEDIMENT, HISTORICAL PENGUIN POPULATION, ELEMENTAL GEOCHEMISTRY, STRONTIUM ISOTOPE

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Historical processes and trend modeling of Qinghai Lake level changes

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The Qinghai Lake level had been experienced intensive changes due to the climate changes and tectonic movement of the lake basin in the Holocene. As the different climate conditions of the combination of water and heat regime, cold wet or warm dry would be main reason for lake expanding or shrinking. And human activities have also been playing a remarkable impact on lake level descending in recent decades. Based on the scenario of future climatic change and the trend of strengthened human activities in the catchment, a forecast for the Qinghai Lake level change has been given by using a statistic-dynamic model that it would be keeping on descending in future decades because of the bi-forcing of global warming and human activities, which would lead the ecological environment to get worse. Therefore, conservative countermeasures should be considered to adapt the future regional environment change and keep the regional sustainable development.

CLIMATE CHANGE, HUMAN IMPACT, LAKE LEVEL CHANGE, QINGHAI LAKE

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Increased variability of monsoonal precipitation since 1910s: Tree-ring evidence from the East Asian monsoon margin areas

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Sabina Przewalskii and *Pinus tabulaeformis* tree-ring widths have been used to reconstruct precipitation variations in the regions of Dulan, the northeastern Tibetan Plateau, and Helan Mountain for the last 200 years. The annual precipitation reconstruction (from prior to July until current June) accounts for 60% and 52% of the instrumentally recorded precipitation variance, respectively. The reconstructions display low-frequency oscillations and many dry/wet intervals. Analysis of the standard deviation of precipitation reconstructions, calculated using moving windows, shows that the precipitation reconstructions display an apparent increase in their variability since the early 1910s. This corresponds to the time when the temperature increased in the northern hemisphere.

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Carbon isotope ratios of preserved cutin-suberin biopolymer as a highly sensitive tracer for studying C4-C3 plant dynamics in the Chinese Loess Plateau

Weiguo Liu, Yongsong Huang

Carbon isotopic compositions of alkenes from loess-paleosol sequence in China Loess were measured by pyrolysis/gas chromatography/isotopic ratio mass spectrometry. Thermochemolysis products of the insoluble residues were characterized using GC/MS, and they are mainly from aliphatic hydrocarbon. The dominant aliphatic compounds are n-alkenes that ranged from C9 to C17 for the loess samples. Fluctuations in the carbon isotopic composition of the Xifeng loess-paleosol profile, range from -27‰ to -18.5‰ for the past 40 kyr. $\delta^{13}\text{C}$ values in colder climates (last glacial) are depleted in ^{13}C by approx. 3‰ relative to those in warmer climates (deglacial and Holocene). This suggests that the temporal variations of the $\delta^{13}\text{C}$ values for alkenes from plants cutin exhibit a close relationship with glacial-interglacial cycles. The result is also closely consistent with those from total organic carbon in same loess-paleosol profile. This investigation (i) reveals that plant root contribute major source of soil organic matter in the China loess sediment, (ii) makes sure that carbon isotopic composition of the soil total organic matter is reliable paleovegetation record for the China loess sediments.

PY-GC-IRMS, CARBON ISOTOPE, ALKENES, PLANT CUTIN, LOESS

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Analysis of the status of a mixed semi-arid woodland in response to charcoal production in Elangata Wuas, Kajiado district, Kenya

Meshack Malo

Understanding charcoal production impact on the woodland status is vital for sustainable management given increasing charcoal demands from growing urban populations. The status of a mixed semiarid woodland was assessed in relation to charcoal production in Kajiado district southern Kenya. Status of the woodland was assessed from 72 circular sample plots and the historical perspective established using maps and discussions with elders. Plots measuring 0.05 ha were assessed counting seedlings, saplings and measuring tree diameter at breast height along altitudinal gradient from the hilltops to the plains. Charcoal production process and efficiency from traditional earth kilns were investigated by comparing outputs and inputs to understand losses. Results show tree cover has increased with discontinuity in species along altitudinal gradient.

Tree density decreases from the hilltop to the plains with failure in regenerates especially at the sapling class. Charcoal recovery rate averaged 8% and preference was for *A. tortilis*, *A. mellifera* and *B. aegyptiaca* in that order with basal diameter >15 cm for charcoal production. Estimates show supply balanced with demand and points the problem of charcoal production to the low recovery rates.

DRY WOODLAND, CHARCOAL PRODUCTION, SUSTAINABLE EXTRACTION

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Holocene climate variability along the North Atlantic European margin: Evidence from speleothem trace elements.

Siobhan McGarry, Chris Hawkesworth, Ian Fairchild

The forcing mechanisms of high-frequency climate variability on sub-millennial timescales during the Holocene are poorly understood. The ASCRIBE (Atlantic Seaboard Climate Reconstruction Including Bounding Errors) project tests whether examples of relatively cold Holocene climate (e.g., 8.2 ka event, Little Ice Age) can be attributed to variations in the strength of the Thermohaline Circulation in the North Atlantic (resulting in regional cooling) or North Atlantic Oscillation-like changes (resulting in a dipole effect). Enhanced westerlies during a positive NAO result in wetter and warmer conditions at mid-latitudes coincident with drier conditions in the west and north Mediterranean. Reduced westerlies during a NAO result in drier and colder conditions at mid-latitudes and a wetter Mediterranean. Such variations in precipitation and wind strength may be recorded by cave speleothems. Trace element variations in dripwaters and speleothems often show a relationship to cave hydrology, reflecting amounts of infiltrating precipitation. In addition variations in speleothems strontium reflect the flux of sea spray and hence are a proxy for westerly wind strength. Thus speleothem trace elements may record variations in these key NAO characteristics. Laser-ablation ICPMS analyses of trace elements in PIMMS U-Th dated aragonite speleothems from caves in Northern and Southern Spain, are presented. This provides high-resolution records of climate variability during the last 1-2 ka and 8.2 ka. This data is complimented by other speleothem climate proxy records within ASCRIBE allowing potential variations in precipitation and wind during these key periods of the Holocene to be detected and the underlying forcing mechanisms better understood.

SPELEOTHEM, HOLOCENE, TRACE ELEMENT, ARAGONITE, NAO

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Integration of the clastic-organic varve record from Finland with a pollen-based climate reconstruction for solving the Holocene seasonal temperature patterns in high latitudes

Antti Ojala, Teija Alenius, Heikki Seppä

We aimed to improve our understanding of the long-term evolution and seasonal patterns of the Holocene climate changes by combining the paleoclimatological interpretation of seasonal-scale varve record of Lake Nautajärvi, with an annual mean temperature reconstruction carried out from pollen data. While the varve record reflects predominantly the sedimentological dynamics within the lake basin and its catchment, the pollen record is derived from larger area representing vegetation and pollen-production dynamics over a considerably larger region. Beginning at 9,300 years ago, the Tann record and the organic varves and pollen show roughly comparable trends, indicating a more direct influence of climate on the physical properties of the varves. The rising trends of Tann and the organic varves reached the Holocene maximum levels at about 7,000 (Tann) and at 6,000 years ago (summer varves) and stayed at this level until about 4,200 years ago. The pollen-based Tann suggest that during this period the Tann values generally 2.0-1.5°C higher than the modern reconstructed values. Records have a steadily falling trend at 4,200 years ago, followed by a slow, steady summer cooling. The patterns of the Tann reconstruction and varves during the last 2,000 years are less reliable, due to agricultural activities within the catchment. Varve data shows periods of increased catchment erosion at 7590-7530 BC, 7450-7400 BC, 7220-7110 BC, 7000-6000 BC, 5400-5200 BC, 4400-4000 BC, 2700-2400 BC, ca. 1500 BC-AD 500, and AD 1400 onwards, strikingly different from the summer varve and Tann patterns.

VARVES, POLLEN, HOLOCENE, TEMPERATURE, LAKE SEDIMENT

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Climatic changes reflected in two western European bogs during the last 4500 cal BP

Pirita Oksanen

As part of an EC-funded project ACCROTELM, two raised bogs, Ballyduff (central Ireland) and Pedrido (northern Spain), have been investigated by means

of plant macrofossil analysis and AMS radiocarbon dating. One core from both sites has been studied at 5 cm intervals for the last 4500 cal BP years. Additionally, the period between ca. 1150-150 cal BP has been studied for every 1 cm for the Irish site. 16 radiocarbon dates are available; 50 more samples will be dated later to allow wiggle-matching of the dates. In Ballyduff, *Sphagnum imbricatum* is the dominant species until ca. 1380 cal BP. After that, several shifts between wetter and drier conditions are traced; the other main species involved are *S. cuspidatum* and *S. capillifolium*. The latest change into *S. cuspidatum* occurred at ca. 385 cal BP. *S. imbricatum* (and *S. tenellum*) disappeared from the records at ca. 175 cal BP, and *S. papillosum* first appeared at ca. 125 cal BP. The replacement of *S. imbricatum* by *S. papillosum* happened in Ballyduff later than in most studied bogs over Ireland and Britain, dating to the late Little Ice Age. It seems to be the last stage of a development, which suggests gradual and repeated deterioration of climate since ca. 1380 cal BP. In Pedrido, the conditions are very dry almost throughout since 4500 cal BP, supporting mostly Poaceae and Ericales dwarf-shrubs. A short pool period with *Sphagnum cuspidatum* is recorded in Pedrido at ca. 75 cal BP, possibly indicating cool climate after the Little Ice Age, but before the early 20th century warming.

CLIMATE CHANGE, PLANT MACROFOSSIL ANALYSIS,
WESTERN EUROPE

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Pattern of land use and land cover change in the Lagos coastal area of Nigeria

Adeyinka Okude

Coastal and marine area provides a whole range of diverse and valuable services to mankind. Such services include the provision of resources, living space, and industrial location, development of leisure and tourism activity and aesthetics. However, this great attractiveness of littoral areas for human settlements have produce strong changes in coastal environments and processes and at the same time, increasing the degree of risk, as human occupancy of a coastal zone transforms natural processes into risk. This complexity in the human-environment interactions within the coastal system and the surrounding system makes it imperative for the understanding and evaluation of the processes of change taking place. The Lagos coastal area in Nigeria is associated with a high degree of urbanization and industrialization with attendant changing pattern of land use and land cover. Therefore, long term studies are essential to understand the effects of this changing pattern. Thus, to understand the impact of the human-environment interactions on the Lagos coastal area, Satellite imageries covering 4 periods (1986, 1990, 1995 and 2002) using GIS were

digitally analyzed to track changes in the land use and land cover of the area over this period of 14 years (1986-2002). Findings in this study have shown a significant spatio-temporal variation in the rate of gain and loss amongst the different land use/land cover category. But of utmost relevance is the near complete loss of the region's ecological biodiversity.

LAND USE, LAND COVER, RISK, ECOLOGICAL
BIODIVERSITY, SPATIO-TEMPORAL

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The importance of paleoscience for environmental management and sustainable development in Africa

Daniel Olago

The African continent, one of the most vulnerable regions to climate change, is subject to frequent droughts and famine and other climate related disasters including floods, landslides and climate-related diseases. Africa's environment is closely linked with its climate, so that climatic constraints have been a major force in the development of vegetation, soils, agriculture and general livelihood. In recent decades, for example, Africa has experience prolonged droughts. Indeed, persistent droughts, well beyond the range of those recently experienced, have been common in the past, and there is a high possibility of their occurrence in the future. Most Africans depend largely on the utilization of land-based resources, as well as on freshwater lacustrine and riverine systems as sources of potable water, fish, transport, etc. Most of Africa's population is, therefore, highly vulnerable to climate variability and change, and this is exacerbated by the rapidly growing population, rampant poverty and lack of alternative livelihoods. Due to the relatively short temporal instrumental record of climatic parameters, there needs to be support for research and education into high-resolution sedimentary and other types of proxy climate records over the past millennium in order to anchor and provide the envelop within which climate change and variability has oscillated in the long-term. Indeed, a major constraint to sustainable development planning is the lack of such data for long-term planning. Many paleorecords from Africa demonstrate the utility of such data for development of policies in sustainable environmental management and planning.

AFRICAN PALEOSCIENCE, ENVIRONMENTAL
MANAGEMENT, SUSTAINABLE DEVELOPMENT

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Accurate extraction of multiple periodic variations in Himalayan tree-ring widths through wavelet transform

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We report here the observation of multiple periodic variations in the tree-ring widths of the Himalayan region, through the continuous wavelet transform. Ring-width chronology of deodar tree from Joshimath (1584-1999 years) and Uttarkashi (1500-2002 years) in the western Himalayas, reveal wavelet amplitude variations in time periods of 11, 22 and 42 years, some of which are correlated with solar flares. Similar analysis of the pre-monsoon (March-April-May) temperature anomalies (1876-2003) relative to 1951-1980 mean, clearly show anti-correlation with the tree ring chronology data. Both continuous and discrete wavelets have been used, in order to ensure that, the observed variations are genuine and not an artifact of wavelets employed. In continuous wavelet transform, we have applied Morlet and Mexican hat wavelets at scale intervals 1 - 64 years, since the trees growing on moisture stressed sites are not sensitive to record centennial timescale variations in their tree-ring growth patterns. Very interestingly, the study of wavelet transform maxima reveals inversion behavior in the periodic variations at around the year 1750.

HIMALAYA, JOSHIMATH, UTTARKASHI, WAVELET TRANSFORM, MORLET WAVELET

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A high-resolution paleoclimate record of the last 1,200 years from stalagmites of the Longquan Cave, Guizhou, China

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Longquan cave is located 5 km NE of Libo County, Guizhou Province (25°29'N, 108°5'E), at an elevation of 550 m. Stalagmites L1 and L2 were collected deep below the cave surface. Eighteen ICP-MS ²³⁰Th dates and 455 $\delta^{18}\text{O}$ measurements were made at L1 and L2.

The time ranges of L1 and L2 are 1000 yr and 1270 yr, respectively, and the $\delta^{18}\text{O}$ records resolve 3.8 yr and 7.8 yr on average. After analyzing oxygen isotope data, we get identical results for L1 and L2. The curve shows that no modern warming is recorded. Ten climate stages can be distinguished between 725 and 1900 yr AD. We compared the smoothed $\delta^{18}\text{O}$ curve of the stalagmites with average temperature curves from phenological recordings including the dates of burgeoning and blossoming and the number of snow days in Central-East China based on historic literature sources. Good similarity was found between the stalagmite and the phenological records. Moreover, the 30-year smoothed stalagmite $\delta^{18}\text{O}$ records match well with the GISP2 curve. From 1190 to 1300 yr AD, the GISP2 record shows a conspicuous warm peak, but the stalagmite and average winter temperature records show low warm peaks. These small-scale differences might reflect the differences in regional climate change towards warm-dry climate in low latitude Asian monsoon areas and towards warm-wet climate in high latitude areas during the Medieval Warm Period. During the Little Ice Age, the three temperature records correspond well with respect to their temperature maxima and minima.

STALAGMITES, TIMS-U SERIES AGES, PALEOCLIMATE, LONGQUAN CAVE

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Fluctuations in paleo-temperature and geological boundaries in Karewa Basin, North India

Hossein Sabetamiri

The study area is a petroliferous basin in Kashmir Valley adjacent to commercial oil fields in Pakistan. The pattern of isotopic fractionation and their positive (+) $\delta^{13}\text{C}$ values indicate an oceanic event, corresponding to relatively high sea level stand, plus relatively high paleotemperature, which may also correspond to increased carbon content in marine sediment of the basin. Increase in negative $\delta^{18}\text{O}$ with that of positive $\delta^{13}\text{C}$ may reflect either increasing temperature or the influx of meteoric water, and $\delta^{18}\text{O}$ may be related to the paleohydrology of the basin and evolution of diagenetic Solution Interpretation of the progressive. The negative trend of $\delta^{18}\text{O}$ in the area has led the author to consider this as evidence for increasing temperatures of precipitation of new calcite or dolomite, change in $\delta^{18}\text{O}$ values have been related to paleotemperature and paleo-salinity fluctuation in ocean surface water. After uplift, another possibility for further recrystallization occurs in the presence of isotopically light water may cause appreciable shift in $\delta^{18}\text{O}$ values in the system such a shift observed in the present data may be related to the depositional history, basinal condition, sea level changes, etc. On regional scale in the broader context of Permian-Triassic geological setting.

ISOTOPE $\delta^{13}\text{C}$ AND $\delta^{18}\text{O}$, PALEOTEMPERATURE, GEOLOGICAL BOUNDARIES, PETROLIFEROUS BASIN, KAREWA BASIN, INDIA

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Changes in temperature and effective humidity during the Holocene in south central Sweden

Heikki Seppä, Dan Hammarlund, Karin Antonsson

We report a 10,000 yr quantitative record of annual mean temperature, based on pollen-climate transfer functions and pollen-stratigraphical data from Lake Flarken, South central Sweden, and compare this record with a reconstruction of effective humidity, as reflected by $\delta^{18}\text{O}$ stratigraphy of lacustrine carbonates from Lake Igelsjön, 10 km from Lake Flarken. The relatively low annual mean temperature and high effective humidity suggest a maritime early Holocene climate, seemingly incompatible with the highly seasonal solar insolation configuration. We argue that the maritime climate was due to a stronger-than-present zonal flow, enhanced by the high early-Holocene sea-surface temperatures in the North Atlantic. The maritime mode was disrupted by the abrupt cold event at 8200 cal yr BP, followed at 8000 cal yr BP by a stable Holocene Thermal Maximum. The latter was characterized by annual mean temperature values about 2.5C higher than at present and markedly

dry conditions, indicative of stable summer-time anti-cyclonic circulation, possibly corresponding with modern blocking anti-cyclonic conditions. The last 4300-yr. period is characterized by an increasingly cold, moist and unstable climate. The results demonstrate the value of combining two independent paleoclimatic proxies in enhancing the reliability, generality, and interpretability of the paleoclimatic results. Further methodological refinements especially in resolving past seasonal climatic contrasts are needed to better understand the role of different forcing factors in driving millennial-scale climate dynamics.

POLLEN, STABLE ISOTOPES, HOLOCENE THERMAL MAXIMUM, ATMOSPHERIC CIRCULATION

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A multi-proxy paleoclimatic/paleoceanographic investigation of Eastern Arabian Sea sediment cores

R. Shankar, C.N. Prabh

A multi-proxy study of two eastern Arabian Sea sediment cores (2,000 and 2,400 m) suggest the following: • SST and/or salinity varied significantly during the last 200 ka. A decrease in SST (~2) and an increase in salinity (up to 1 psu), as a result of variation in the E-P balance due to a strong NE monsoon, were recorded for the last glacial period. Strengthening of the SW monsoon during interglacial periods and the subsequent increase in precipitation reduced the salinity. • Magnetic mineral input was high/low during glacial/interglacials. • Glacial periods had coarser magnetic grains and interglacial periods, finer grains because of intense chemical weathering. • The northern hemisphere glaciation had an effect on the aridity cycles of the entire Arabian Sea. • Rock magnetic studies of sediment cores from the Western continental shelf of India indicated a wet phase (increased rainfall) during early Holocene. • Taxa like Chenopodiaceae/Amaranthaceae and Artemisia could be used as markers for arid climate and Poaceae and Piperaceae for humid climate. MIS 2, 4 and 6 were characterized by high Chenopodiaceae/Amaranthaceae suggesting a cold and dry climate and MIS 1, 3 and 5 by high Poaceae and Piperaceae suggesting a warm and wet climate over the Indian subcontinent and the eastern Arabian Sea. • Paleoproductivity reconstructions based on *F. profunda* and C_{org} are similar, being high/low during glacial/interglacial periods. • The Earth's precessional cycle (23 ka periodicity) exerted a significant control over the monsoon climate of the Indian subcontinent and the Arabian Sea.

PALEOCEANOGRAPHY, PALEOCLIMATE, EASTERN ARABIAN SEA, MULTI-PROXY, LATE QUATERNARY

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Low and high frequency patterns of temperature changes in Northern Eurasia

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Tree-ring chronologies of about 2500-yr have been designed recently for the Subarctic Asian region (Eastern Taimyr and Northeastern Yakutia). Correlation analysis as well as the results of a simulation model reveals the leading role of summer (June-July) air temperature for tree ring growth in Northern Eurasia. In the different Subarctic sectors (Sweden, Yamal, Taimyr, Indigirka), June-July temperature of the same years does not show significant correlation but decadal and especially longer fluctuations of radial growth in the different sectors are obviously synchronized, and show stable and significant correlations with annual mean temperature. However, the correlation between summer temperature and annual mean temperature for the last 2000 yr is not higher than 0.35 ($p < 0.05$). It suggests the existence of some additional mechanisms that cause the synchronous character of long-term changes of tree growth over the northern hemisphere.

NORTHERN EURASIA, MILLENNIAL TREE CHRONOLOGIES, TEMPERATURE, CLIMATIC CHANGES

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Paleoenvironment of the Tonle Sap Great Lake

Sotham Sieng

The Tonle Sap Great Lake has close relation to the life and culture of Cambodia since the Angkor time and plays an important role in reducing the flood in the lowland of Cambodia. It is clear that the death of the lake will seriously affect the life of the Cambodian people. To clarify the past and present environmental changes in the lake area, a joint research study was carried out to study the evolution of the lake. The study was based on geology, sedimentology, micropaleontology, clay mineralogy, palynology and radiocarbon dating. The result of the study led to the conclusion that: •The paleo-lake was considerably smaller freshwater isolated

lake(s), rather than a large lake as it is at the present time. •The paleo-lake(s) was isolated from the major fluvial system such as the Mekong river; and muddy sediments derived mainly from alluvial plains around the lake were filling up the lake(s). •The present environment of the Tonle Sap Great Lake appeared at around 5.5 ka and the environment has existed continuously till the present day. •The sedimentation rate in the lake was about 1.2 mm/year since 6,070 to 5,620 yr BP, and drastically decreased to 0.1 mm/year since 5.5 ka to present)

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Automated chronology building in speleothems

Claire Smith, Ian Fairchild, Andy Baker

The use of speleothems for high-resolution climate reconstruction is dependent upon the ability to accurately resolve the chronology to an annual timescale. In the absence of annual laminae it is possible to achieve annual resolution of a speleothem by counting annual cycles in the geochemical stratigraphy. This is, however, a generally subjective process. Presented here are the procedure and results of an automated, trace element peak-counting program developed using Matlab®. The output is encouraging and shows the value of such a tool for refining estimates of the duration of significant climatic events (e.g. the 8.2 kyr event), and for the verification of dates derived from laminae counts or U-series methods. When annual laminae are present, researchers are faced with the arduous task of counting the individual laminae. The above program was adapted to make it applicable to identifying peaks within a color intensity line profile taken from an image of a laminated sample. This proved successful, with an accuracy equivalent to that achievable via manual laminae counting. The less time-consuming, objective nature of these chronology-building tools provides an efficient and more robust dating technique.

SPELEOTHEM, LAMINAE, ANNUALLY-RESOLVED

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Problems and achievements of millennial climate reconstruction

D.M. Sonechkin, N.M. Datsenko, K. Holmgren, A. Moberg

Approaches and methods of the problem of the millennial reconstruction of past climate variations are discussed. A mathematically strict definition of the problem as a problem of filtering heterogeneous noisy

and systematically biased multiscale data records is given. In the frame of this definition a comparison is done of the traditional regression-based method of reconstruction (used in many earlier published millennial reconstructions of northern hemisphere mean temperature) with the recently developed time-scale dependent method. A 2000-year-long reconstruction recently created by the authors is represented, and the values and possible shortcomings of this reconstruction are considered. Some possible ways of improvements of this reconstruction and similar ones are discussed, especially in respect of the use of different kinds of low-resolution proxy data records. Fingerprints of millennial- and centennial-scale climatic cycles are indicated in the reconstruction. Perhaps these cycles are excited and maintained by some quasi-periodic forces of external origin. As an example of such a millennial cycle a chain: Medieval Warm Period–Little Ice Age–current warming is considered. An example of a centennial cycle can be seen in the two-step character of the current warming. Some prospects of the climate evolution are presented for a nearest future of several decades.

MILLENNIAL PALEOCLIMATE VARIATION RECONSTRUCTION, PROXY DATA, CLIMATE CYCLES

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Vegetation response to climate change in Ireland and north-west Spain over the last 4500 years

Bettina Stefanini

This research forms part of ACCROTELM, a three-year project funded by the European Commission. ACCROTELM (Abrupt Climate Changes Recorded Over The European Land Mass) aims to quantify the extent and timing of climate change events during the late Holocene. High-resolution multi-proxy analyses of wiggle match dated peat cores are used to determine the timing of climate change events from eight sites across Europe. The methods are essential tools in a comparative analysis between techniques and sites and are used to quantify the sensitivity of each to changes in climate. My research project covers humification and microfossil analysis from an Irish and a Spanish core. The degree of humification in ombrotrophic mire systems is thought to be directly linked to bog surface water and thus to the climate at the time of peat formation. Microfossil analysis on the other hand examines the changing patterns of pollen and other palynomorph deposition on the mire surface through time. Preliminary results of humification

analysis indicate a series of wet shifts in both Spain and Ireland during the late Holocene. These wet shifts are correlated with the prevalence of non-pollen palynomorph indicators. Landscape vegetation change inferred from regional pollen data from Ireland show that significant changes coincide with known climatic events. Future work will concentrate on increasing the resolution of the pollen data.

CLIMATE CHANGE, POLLEN, HUMIFICATION, NON-POLLEN PALYNOFORMS

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Luminescence variations in fast growing stalagmites from Uppsala, Sweden

Hanna Sundqvist, Andy Baker, Karin Holmgren

Speleothem luminescence is predominantly generated by organic acids formed in the overlying soil by the breakdown of plant material. In shallow limestone caves in the UK, luminescence intensity has been demonstrated to vary seasonally, with a winter luminescence peak caused by flushing of organic matter from the soil zone by high winter rainfall. Here, we present a study of luminescence intensity variations in two fast growing stalagmites from a cellar vault in Uppsala, southeast Sweden. The results indicate that variations in luminescence intensity in the stalagmites are annual. If so, the speleothems would be 10-15 years old and have had a growth rate of 3-8 mm year, which is a growth rate that is similar to other fast growing speleothems that have formed from the reaction of lime mortar and carbon dioxide. It is likely that the annual peaks of the luminescence record represent a flush of organic material during late autumn precipitation events. Due to problems in finding a suitable absolute dating method this assumption can not yet be firmly tested.

STALAGMITES, LUMINESCENCE, SWEDEN

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Abrupt cooling: Can we make predictions?

Ming Tan, Binggui Cai

The National Climate Center of China Meteorological Administration announced that, on 16 December 2004, the country was experiencing the 19th warmest winter, because the temperature had been significantly higher than normal in most regions since 1 December. That

meant the average temperature of three months of the winter would be 0.5°C higher than the averages of 1971 to 2000. Over the next two months, however, many areas experienced severe cold. Finally, China Meteorological Administration said that, on 3 March 2005, the average temperature of this winter was -0.4°C for the whole nation, which was just consistent with the normal. We are then suspicious of the prediction of global temperatures for the coming century if a monthly abrupt cooling so easily cancels a short-term climate warming. Meanwhile, this also prompts us to go back in time to recheck the proxy records to investigate how and why abrupt coolings occur. We are not able to make a confident prediction of global warming in the 21st century unless we can, at the same time, predict all abrupt coolings on inter-annual to century scales. Recognizing all abrupt cooling events on inter-annual to century scales recorded in annually resolved proxy records over the past millennia is necessary for simulating the climate in the future century. We can examine, e.g., whether the temperature once abruptly dropped from the MWP to the LIA. Stalagmites and tree rings from China have together given positive evidence.

GLOBAL WARMING, ABRUPT COOLING, PREDICTION, PROXY RECORDS

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Vegetation and climate changes in the high mountains on the Balkan peninsula (Southeast Europe) in postglacial times

Spassimir Tonkov

Pollen and plant macrofossil analyses supplemented by radiocarbon chronology were conducted on lacustrine sequences from glacial lakes located in the Rila (2,925 m) and Pirin Mountains (2,914 m) on the Balkan peninsula. The vegetation response to the Late Glacial climatic fluctuations after 13,000 ¹⁴C yr BP was characterized by the widespread of mountain herb vegetation dominated by *Artemisia*-*Chenopodiaceae*-*Poaceae* with sparse stands of *Pinus* and shrubland of *Juniperus*-*Ephedra*. The identification of pollen and macrofossil remains from a number of thermophilous coniferous and deciduous trees suggests that they survived the harsh climatic conditions in refuges at lower altitudes where moisture was sufficient for their growth. The reforestation dynamics in early Holocene times (9600-8800 ¹⁴C yr BP) after the termination of the stadial Younger Dryas started with *Betula* forests and groups of *Pinus* while deciduous forests with *Quercus*, *Tilia*, *Ulmus* and *Corylus* gained dominance at low altitudes between 8800 and 6800 ¹⁴C yr. BP. An increase in humidity and precipitation and the establishment of suitable edaphic conditions after 6800 ¹⁴C yr BP initiated the formation of a coniferous belt

composed of *Pinus* and *Abies*. The forest dynamics in late Holocene ended with the invasion of *Fagus* and *Picea* after 4000 and 3000 ¹⁴C yr BP, respectively. Indications of long-lasting anthropogenic interference in the natural forest cover, expansion of agriculture in the foothills and livestock grazing in the mountain pastures, are clearly recorded after 2200 ¹⁴C yr BP.

VEGETATION, CLIMATE, POSTGLACIAL, MOUNTAINS, SE EUROPE

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Oxygen isotopes in diatom opal—a reliable paleoclimate proxy? Testing isotope fractionation against spatial and temporal climate variability

Jonathan Tyler, Melanie Leng, Vivienne Jones, Richard Battarbee

The oxygen isotopes of biogenic silica in sedimentary deposits offer potential for paleoclimate studies, especially in locations where conditions do not permit the preservation of calcium carbonates. Recent advances in the preparation of pure biogenic silica and in analytical procedures for measuring the oxygen isotope ratios have heightened the need for data concerning the processes by which siliceous microfossils (e.g., diatom frustules) obtain oxygen isotopic signals, the precise relationship between oxygen isotopes in water, temperature and isotope fractionation in biogenic silica, and the influence of water chemistry (e.g., pH) on the process. Rigorous monitoring of a remote, high altitude lake in Scotland (Lochnagar) and 'natural culturing' of benthic diatoms on artificial substrata has been carried out to obtain a monthly signal of oxygen isotopes in diatom silica. In addition, surface sediments from lakes across a wide climatic gradient in Europe and North America, and whose waters have isotope ratios close to mean annual local precipitation have had diatom silica isolated and analyzed for oxygen isotopes. Both datasets permit rigorous comparison between local climate, limnology and sedimenting biogenic silica. Preliminary data are presented and discussed in terms of the potential or otherwise for oxygen isotopes in biogenic silica as a reliable paleoclimate proxy.

OXYGEN ISOTOPES, BIOGENIC SILICA, PALEOCLIMATE, LAKES

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Temperature variations describing the Arctic environment using the European North as an example

Svetlana Vidyakina

This research analyses peculiarities of changes in the regional temperature characteristics in northern Europe for the last one thousand years based on indirect (geothermal, dendrochronological and historical) data. According to geothermal reconstructions it is possible to allocate the Little Ice Age, the maximum of which lies around 1540-1560. The end of this period is recorded at approx. 1850. The last warming of non-anthropogenic character was recorded in 1920-1950, contemporary warming since 1970 years. This trend is proved by dendrochronological reconstructions until 2003. The analysis of low frequency (Potter-filtered) components of meteorological air temperatures from the investigated region from the 19-20th centuries has distinguished a dominant component of 80-100 years for the Arctic stations, with contemporary warming since the year 1970 and correlation with ground temperatures. The obtained results suggest, that climate in the Arctic and adjacent regions will continue to be dominated by natural century-scale cycles, superimposed by the contemporary warming trend of air temperatures.

TEMPERATURE, VARIATION, FILTER, GEOTHERMAL RECONSTRUCTION, DENDROCHRONOLOGICAL RECONSTRUCTION

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Recent climatic variability in the Northeastern Tropical Pacific recorded in coral records from San Benedicto Island, Revillagigedo Archipelago, Mexico.

Julio Villaescusa, José D. Carriquiry

The eastern subtropical Pacific is an area where coral records are relatively scarce. We have developed a seasonally resolved, 174-year long, coral (Porites) Sr/Ca and $\delta^{18}\text{O}$ record from San Benedicto Island, Revillagigedo Archipelago, located at the tropical/subtropical transition zone in the Northeastern Pacific (NEP). The skeletal Sr/Ca reflects the past sea surface temperature variability at interannual and multidecadal timescales. The interannual (3-7 years) Sr/Ca variability is highly coherent and in phase with the Niño 3.4 SST anomaly. Strong interdecadal scale variability in the Sr/Ca record is clearly related to the Pacific Decadal Oscillation (PDO). Moving correlation coefficients (21-year window) between the tree ring and instrumental PDO indexes, and the interdecadal San Benedicto Sr/Ca record show a positive correlation in the 20th century, except in short periods centered in 1900 and 1950, when the PDO index is not synchronous with the skeletal Sr/Ca variability; and before ~1880 when the correlation in both records are low or negative. The

$\delta^{18}\text{O}$ of seawater ($\delta^{18}\text{O}_w$) reconstructed from $\delta^{18}\text{O}$ and Sr/Ca appears to respond to the local seasonal variability in salinity ($r=0.372$, $\alpha<0.05$, period 1980 to 1998), and with the long-term hydrologic balance (E-P) changes. The coral reconstruction of ocean- $\delta^{18}\text{O}_w$ variability is consistent with the seasonal changes in Intertropical Convergence Zone (ITCZ) in the eastern tropical Pacific. The correlation between both records shows a variability pattern coherent with interdecadal ENSO variability.

CORALS, EASTERN PACIFIC, CLIMATE RECONSTRUCTION, ENSO, PDO

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Variations of dust storm frequency in the northwest China during the past 600 years as reflected by the Malan ice-core record

Ninglian Wang

The Malan ice cap, with an area of 195 km² and a summit elevation 6056 m asl, is located in the Kunlun Mountains in the northern Tibetan Plateau. In 1999, a 102 m ice core was drilled at 5680 m asl where the 10-meter borehole temperature was about -6.5°C. The core was returned frozen to the Key Laboratory of the Ice Core and Cold Regions Environment of the Chinese Academy of Sciences where ^{18}O was measured by Gas Stable Isotope Ratio Mass Spectrometry (MAT-252). We realized that the ratio of visual dust layer thickness to ice thickness in a given time period can be used as a proxy of dust storm frequency in the northwest China. It was found that dust storm occurred frequently in two periods during the past 600 years, i.e., from the early 15th century to the middle 16th century, and from the late 18th century to the early 20th century. By statistical analyses of the variations in dust storm frequency and ^{18}O (a good proxy for air temperature) recorded in the core, it was found that there is a strong negative correlation between them on the decadal to centennial timescales. This is very important for the study on the correlation between atmospheric dust concentration and air temperature.

MALAN ICE CORE, DUST STORM FREQUENCY, NORTHWEST CHINA

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Timescale dependence of the northern hemisphere temperature response to volcanic and solar forcing in the last millennium

Nanne Weber

The climate of the last millennium has been simulated using the intermediate-complexity ECBilt model. ECBilt contains a dynamic atmosphere, a global 3-D ocean model and a thermodynamic sea-ice model. A number of integrations were done, using different combinations of past forcing factors (reconstructed solar and volcanic forcing, orbital forcing). Northern hemisphere (NH) temperatures clearly show a number of extended warm and cold periods, which are to a large extent related to variations in the external forcing. A timescale analysis shows that the response in atmospheric parameters can be characterized as the direct response of a system with a large thermal inertia. As a result the climatic sensitivity to solar forcing increases for longer timescales, while the sensitivity to volcanic forcing levels off at decadal timescales. A comparison of the model results with recent paleoclimatic reconstructions of the NH temperature shows a similar timescale-dependence in the response to external forcings, but lags are longer in the data than in the model.

NH TEMPERATURE, LAST MILLENNIUM, TIMESCALE ANALYSIS, MODEL-DATA INTERCOMPARISON, SOLAR AND VOLCANIC FORCING

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Gray scale in a stalagmite from Heshang Cave in the central Yangtze Valley of China: Application for seasonal resolved climate reconstruction

Kaihui Xiao, Chaoyong Huang

Variations in the color of speleothems is mainly the consequence of the local hydrological conditions, which are linked to the local climate and environment. Here, we measure the grey scale along stalagmite sections from Heshang Cave, Hubei Province, China, using professional software ENVI4.1. Grey scale values retrieved from speleothem precipitated in the last century shows clear annual oscillation. In seasonal timescale, the high grey-scale correspond to the light lamina of speleothem calcite, which precipitated in the dry season with low temperature and less rainfall in this area. The grey scale curves correspond well with the past ~100 years rainfall record, implying grey scale can be a proxy of past rainfall.

GREY SCALE, RAINFALL, SPELEOTHEM, SEASONAL RECORD, CLIMATE

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A multiproxy paleolimnology study on a shallow delta lake in Northern Canada

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The Peace-Athabasca Delta is one of the largest inland freshwater deltas in the world. A myriad of shallow lakes, scattered across the delta, provide precious archives of past changes in this important boreal ecosystem. Herein we present multiproxy records from a delta lake, PAD 9, located near Lake Athabasca, one of the Great Lakes of northern Canada. Both 30-cm KB cores and 100-cm Russian core segments were retrieved from the current depocenter of the lake. With the detailed ^{210}Pb dating on the short core, multiproxy records indicate substantial hydroecological changes in the past hundred years. The lake appears to have been inundated by Lake Athabasca before 1910, based on the high abundance of *Fragilaria* diatoms and relatively constant lakewater $\delta^{18}\text{O}$ inferred from sedimentary cellulose. Pronounced river influence on the lake occurred during the interval AD 1910-1930, which is indicated by the highest abundance of quartz, even lower $\delta^{18}\text{O}$ from sedimentary cellulose and striking change in diatom assemblages. After 1930, the lake was progressively separated from Lake Athabasca, becoming an isolated closed-drainage basin. The progressive isolation of PAD 9 from Lake Athabasca, deduced from the KB core, are further confirmed by a set of historical maps and air photos. Preliminary results of the long (Russian) core are also consistent with this recent transition from open- to closed-drainage conditions. Ongoing analysis of the cellulose $\delta^{18}\text{O}$ stratigraphy and other proxies will allow much fuller depiction of hydroecological changes in the lake over the past 2000 years.

PALEOHYDROLOGY, HYDROECOLOGY, STABLE ISOTOPE, DIATOMS, PEACE-ATHABASCA DELTA

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Late Quaternary paleoclimate modeling for the East Asian monsoon regions

Ge Yu

The wealth of paleoenvironmental evidence from China shows that dramatic changes in the strength and extent of the Asian monsoon occurred during the Quaternary, in response to changes in insolation, glaciation, land-surface conditions and human activities. Physically-based models provide a powerful tool for attempting to understand these past changes in climate. The PMIP has examined how the northern hemisphere monsoons responded to changes in climate forcing at the LGM and during the mid-Holocene, but the major focus for comparisons with paleoenvironmental data has been the African and North American monsoons. During 6 ka BP the climate forcings of the ice sheets, atmospheric CO₂ and ocean conditions were not significantly different from today, but the changes in the Earth's orbital parameters resulted in enhanced seasonal contrast in insolation forcing. One question that these simulations cannot address is what an enhancement of the seasonal contrast in insolation would lead to when combined with glacial conditions. There have been some attempts to look at this combination of forcings during the early Holocene but the northern hemisphere ice sheets were rather small at that time and their impact largely local. The period around 35 ka BP during the last interstadial provides an opportunity to examine the joint impact of enhanced seasonal contrast in insolation forcing during an interval when the ice sheets were considerably larger than present or during the early Holocene. An atmospheric general circulation model coupled with land process (AGCM-SSiB), which produces a reasonable simulation of modern climate, was used to explore climate changes in the Asian region at 6 ka, 21 ka and 35 ka BP.

PALEOCLIMATE, MODELING, 35 KA, 21 KA, 6 KA

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Vegetation and environmental history of Dajiuhu Basin since 4000 yr BP by means of macrofossils, pollen and geochemistry

Yan Zhao

A stratigraphic sequence of 120 cm from the Dajiuhu Lake Basin has been studied for pollen, macrofossils and geochemistry. The profile represents the vegetation from ca. 4000 yr BP until today. The vegetation composition in Dajiuhu Area has not changed much, reflecting that it formed before this period. However, some vegetation and climate fluctuations and human disturbances can be clearly seen by pollen, geochemistry and plant macrofossil. Good correlations exist between Rumex, Juniperus, Rhus, Alnus and geochemistry. For macrofossils, Sphagna Sec. Subsecunda and Drepanocladus spec. correspond well with the geochemistry. It shows that

the combination of these methods has good potential for high-resolution reconstruction of vegetation and climate.

DAJIUHU LAKE, POLLEN, PLANT MACROFOSSILS, GEOCHEMISTRY, VEGETATION & ENVIRONMENTAL HISTORY

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A 1300-year record of seabird population on Dongdao Island of South China Sea in response to climate change

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The "Cattle Pond" on the Dongdao Island is a rare freshwater lake on Xisha Islands of South China Sea. From the "Cattle Pond", we collected a 126-cm-long and undisturbed sediment core that contains seabird feces. We determined the concentrations of 26 geochemical elements and reconstructed the historical seabird populations over the past 1300 years. The results show that in the 26-96 cm sediment layer, the concentration-versus-depth profiles of As, Cd, Cu, Se, Zn, P and S are significantly correlated with each other. Furthermore, these elements have a significant assemblage relationship with loss on ignition (LOI) at 550 degree, the measure for the abundance of the ornithogenic organic matters. Above geochemical characteristics, however, were not observed in the upper 25 cm sediment layer notably affected by cattle excrements, and in 97-126 cm almost as coral sand with few organic matters. We used aluminum (Al), a conservative element relatively immobile and rich in clay materials, as a reference element to correct grain size effect on the elemental abundances. The ratios of As, Cd, Cu, Zn, Se, S and P over Al display the similar trends versus depth. It suggests that the assemblage of As, Cd, Cu, Zn, Se, S and P can be used to evaluate the abundance of the ornithogenic input. By Q-mode factor analysis on the elements/Al ratios, we reconstructed the historical seabird populations on the Dongdao Island over the past 1300 years, which showed significant fluctuations. A comparison of the historical seabird populations and sea surface temperature (SST) of the South China Sea over the past 1300 years indicates that SST might have been the main controlling factor on the seabird populations, and in the range of 27-31 degree of SST, the seabird populations were roughly positively correlated with SST.

DONGDAO ISLAND, LACUSTRINE SEDIMENT, SEDIMENT SEQUENCE, SEABIRD POPULATION, SST

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The Inter-decadal climate variability in eastern China during the past 2000 years

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To study climate variability during the past 2000 years is a key aspect for understanding whether or not the variability of recent climate changes exceed maximal variability which occurred in the last 2000 years. Based on the yearly drought/flood grade series at 48-sites and winter half-year temperature series derived from Chinese historical documents, the inter-decadal climate variability over eastern China for the last 2000 years is studied, and the highlights of this study are summarized as follows: (1) Climate warming in the 20th century was prominent and rapid with a rate of 1.1°C per century counted by winter half-year temperature in eastern China. However, during the last 2000 years, the winter half-year temperature variability for alternation of cold/warm epochs was usually more than 1.0°C per century, and the 20th century warming was not the unique one when compared with other rapid warming course before. In addition, during the 20th century, the mean temperature of the warmest decade, the mean temperature of the warmest 30-year and that of the whole century were less than their maximum levels occurred in the last 2000 years respectively. (2) Since AD 500, there existed nine extreme dry decades and eleven extreme wet decades, whose anomaly was more than 2 times standard deviation. In which, the driest decade occurred during 1635-1644, and the wettest decade occurred during 894-903. When viewed the precipitation variability in the 20th century during the long-term change, it is found that the range of precipitation variability in the 20th century over eastern China could not fully represent that for the last 2000 years.

CLIMATE VARIABILITY, INTER-DECADAL, EASTERN CHINA, PAST 2000 YEARS

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Long-term spatial distribution patterns of penguin population in response to climate change in the maritime Antarctic

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Global climate warming has dominant effects on ecosystem structure in the maritime Antarctic, but the ultimate consequences of such climatic changes for marine organisms cannot be accurately predicted because of the difficulty of obtaining long-term datasets on key demographic parameters. Here, we use an indirect method, a biogeochemical method, combining with ^{137}Cs and ^{210}Pb CRS mode dating, to study the spatial dynamics of penguin population on Ardley Island in the maritime Antarctic. Six surface sediment profiles were sampled in the catchments from the different aspects of this island. The typical elements for penguin guano in these sediment multi-profiles were analyzed as the indicators for spatial changes of penguin population. Results show that the levels for typical elements for penguin guano display abrupt decreases from down to the top in sediment profiles A1, A2, A3 and A4, located on the northwest, west, southwest and northeast sides of this island, respectively. However, they display dramatic increases from down to the top in profiles A5 and A6, located on the southeast side. By Q-mode factor analyses, we obtained the spatial distribution patterns of penguin populations on Ardley Island. Over the past one hundred years penguin population showed a sharp decrease and their colonies rapidly contracted on the northwest, west, southwest and northeast sides of this island. Penguin population showed a drastic increase and their colonies showed a rapid expansion on the southeast side, suggesting penguin populations have been shifting to the southeastern beach, which has led to the spatial changes of penguin population on Ardley Island. The factors responsible for this distribution pattern were also analyzed and discussed in details.

PENGUIN POPULATION, ANTARCTICA, ARDLEY ISLAND, GUANO, BIOGEOCHEMICAL METHOD

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Session 2: Humans and their Environment - Past Perspectives on Sustainability

The trend of paleoresearch towards ever higher resolution and towards subrecent historical and archeological timescales requires us to include man as a component in the Earth System. It also enables us to study the effect of climatic/environmental change on past societies. Contributions to this session address both feedback directions of the climate-environment-man system. They do so by presenting high-resolution paleo-data of the last decades to millennia in the context of the archeological and historical records, and by presenting environmental records that contain evidence of human activity.

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<i>Poster Abstracts:</i>	<i>p. 52 - 67 (arranged by first author alphabetically)</i>
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Climate change, human evolution and later adaptation in the Horn of Africa and surrounding regions*Mohammed Umer*

In the Horn of Africa, studies of environmental and climatic changes have focused on two areas: (1) understanding human origins and evolution, and (2) finding continuous evidence during the Late Quaternary. Ethiopia is one of the regions in the Horn and Eastern Africa where the oldest and most important human fossils and cultural remains have been found. However, there have been challenges to find evidence of environmental and climatic conditions during the most important stages of human evolution and later cultural developments, such as the origin of agriculture. Moreover, the influence of climate change on some of the evolutionary transitional stages, including conditions under which *Homo Sapiens* evolved and dispersed out of Africa, have been the subject of discussion. In addition, understanding the roles of climate change and/or human impact in modifying the environment over the last few thousand years has been important in understanding the sustainability of the present environment. This presentation describes environmental and climatic conditions during the following stages: in relation to human origins (prior to 4M yrs), during the Pliocene *Australopithecus Afaransis*, during the transition from *Australopithecus* to *Homo* (at ~2.5 M yrs) and during the origin and dispersal periods of *Homo Sapiens* (post 200 K yrs BP). Emphasis will be placed on postglacial continuous high-resolution evidence, such as from a high altitude lake in Southern Ethiopia and from lake sediment records in the Main Ethiopian Rift Valley. They record histories of deglaciation, Early Holocene warm and moist conditions, and Early Holocene abrupt dryness. Whether the Mid to Late Holocene shift to dryness is due to a general decrease in moisture or to increased seasonality will be discussed. It is hypothesized that this condition might have influenced the late origin of agriculture on the Ethiopian highlands. Finally, a potential site for a long coring project at Lake Tana, in the headwater of the Blue Nile in North Western Ethiopia will be highlighted. Coring and seismic evidence have indicated that the lake dried out and refilled several times during the Pleistocene.

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Human-environment interactions: Past, present and future

John Dearing

Over the past decade, the contribution of paleoclimate reconstructions to our scientific understanding of the present global climate has been acknowledged at the highest international scientific and political levels. This presentation considers the value and scope of extending climate reconstructions to embrace the complexity of interactions between past human activities, climate and ecosystems. It describes the PAGES program Focus 5 'Past Ecosystem Processes and Human-Environment Interactions': a program promoting and coordinating the analysis of past environmental archives, historical documents and instrumental records in order to provide a sound basis for determining both the nature of human-environment interactions and the appropriate approaches for sustainable management of ecosystems. The program is sub-divided into three sub-programs dealing with fluvial systems (LUCIFS), terrestrial ecosystems (HITE) and lake systems (LIMPACS). Each sub-program has specific objectives and work plans, but all utilize similar or complementary methodologies and techniques to reconstruct past environments. Published examples are used to demonstrate some of the ways in which we can 'learn from the past': modern-baseline comparisons; trajectories of change; variability and scale; process-response relationships; complex system behavior; and simulation modeling. It reviews the priorities for the Focus 5 community, including the need to integrate case-studies within biomes, physiographic areas and highly sensitive systems, and the development and testing of mathematical models that can simulate complex human-environment interactions. A new organizational matrix for the regionalization of Focus 5 information is presented which will help promote multi- and inter-disciplinary analyses of existing case-studies within zonal and azonal regions according to the intensity and duration of past human impact. The new scheme will also help identify other regions for which new research is needed, for example highly valued ecosystems, fragile and degraded landscapes, and human societies threatened by projected climate impacts.

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Paleolimnology, pollution and climate change

Rick Battarbee

Lakes are highly distinctive features of the earth's surface. They vary greatly in distribution, size, age, origin, chemistry, biology and in the extent of their alteration by human activity. Lakes close to human settlements, receiving waste-water and run-off from agricultural land, have been very heavily modified by the effects of eutrophication, others with low natural alkalinity close to industrial areas have suffered from acidification, and in many arid and semi-arid regions of the world abstraction of fresh-water for drinking and irrigation has caused severe salinization. Even in the most remote regions that are relatively free from these pressures it is possible to detect the presence of long-range transported air pollutants that accumulate in the food chain. And all lakes are now exposed to additional threats from greenhouse-gas forced climate change acting both directly in terms of changing temperature, precipitation and wind regimes and indirectly through the influence of climate change on catchment land-use and on the behavior of pollutants. Understanding how these pressures combine and interact to change the structure and functioning of lake ecosystems on different time-scales is a central focus of limnological research requiring the combined expertise of both neo-limnologists, paleolimnologists and lake modelers. Here, I am concerned principally with the role of paleolimnology. I will explain how lake sediment records can be used to reconstruct changes in lake status through time and how such records can potentially be combined to provide unique insights into regional and global patterns of environmental change. In particular, I will stress the role of lakes and lake-sediment records in remote regions, and consider whether recently observed changes in remote sites are due to global warming or to other factors.

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Human impacts on ancient environments

Charles L. Redman

There is no greater challenge than to seek a better understanding of the long-term interaction of society and the environment and to use that knowledge to preserve, nurture, and perhaps even to improve upon what we value in environment and society. These interactions can best be understood from a perspective that takes those long-term dynamics into account and that addresses questions from an integrated, often interdisciplinary, perspective on human societies and biophysical environments. Although this issue has attracted wide academic attention only in recent decades, the underlying, coupled human-natural interactions are millennia old and derive in part from the legacies of past choices, beliefs, and actions. Among the various causes for social collapse cited by Jared Diamond in his recent book, "Collapse"; the one that appeared repeatedly in all of his cases was a failure in the decision-making process as it related to coping with environmental challenges. This issue will be discussed in the context of several case studies of ancient societies and with the aim of suggesting general patterns and recommending agendas for research and for action.

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Human impacts of climate anomalies and weather disasters during the past millennium in central Europe: Learning from the past

Rudolf Brázdil, Christian Pfister

Humans and their economy were always sensitive to climate anomalies and to the frequency and severity of weather disasters. Three main climatic periods are distinguished in the past millennium: Medieval Warm Epoch (up to 13th century), Little Ice Age (AD 1300-1860), Recent Global Warming (after AD 1860). Each of these periods experienced significant cold and warm, wet and dry anomalies and changeable weather disasters with different frequency and severity. Prior to the existence of a global network of cheap transportation, weather-related crop failures were the greatest risk in pre-industrial societies. Very high grain price as the basic indicator of well being conditioned significant crises. Many of them (1570/71, 1627/28, 1693/93, 1770/71, 1816/17) were connected to conjunctions of cold springs and wet mid-summers that affected both the quality and the quantity (i.e., the content of nutrients) of the major food staples. Crisis mortality was rather due to a weakening of the immune system against epidemics than to outright starvation. Chroniclers deliberately put a focus on memorable extreme events that affected the amount and the quality of crops. From the 12th century climatic events were increasingly described with reference to the natural sphere of causation. On the other hand, the meaning attributed to the events basically remained in the cultural sphere of causation. In the Christian world the weather was seen as God's birch for whipping humans when he was angry. Another interpretation blamed witches for the occurrence of extreme events what was a basis for witch-hunts. Industrial societies are rather sensitive to interruptions of transport lines or to drought related slow-downs of the energy or water supply. Their more and more complex structure increases losses related to anomalies and weather disasters and future climate change can enhance this tendency. The knowledge from the past is helpful for better understanding of future human impacts of climatic anomalies and weather disasters.

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Sustainability in the period of agriculture: The Near Eastern case

Frank Hole

Agriculture began in the eastern Mediterranean Levantine Corridor about 11,000 years ago toward the end of the Younger Dryas when aridity had greatly diminished wild food resources. During the subsequent Climatic Optimum, agricultural villages spread rapidly but climatic changes on centennial-millennial scales resulted in striking oscillations in settlement in marginal areas. Natural climate changes thus alternately enhanced and diminished the agricultural potential of the land. Growing populations and more intensive land use, both for agriculture and livestock, led to changes in the structure of vegetation, hydrology, and land quality. Over the millennia, political and economic interventions, warfare and incursions by nomadic herding tribes all impacted sustainability of agriculture and the ability of the land to support its populations. In much of the region today, agricultural land use is not sustainable given existing technology and national priorities. The Near Eastern case is instructive because of the quality of information, the length of the record and the pace of change. The modern era is one of unprecedented change in size of populations, agricultural technology, economic forces and technological interventions. In the last half century, the building of dams and canals for irrigation, the mechanization of agriculture, and the introduction of diesel pumps to extract ground water, enabled the spread of agriculture into marginal zones and allowed double cropping, with loss of fallow, in the better zones. While expansion proceeds in some zones, abandonment occurs in others as the ground water is depleted, salts cake the surface, and blowing dust buries fields and settlements following destruction of native land cover. In many places, degradation is effectively irreversible. Sustainability will require elimination of destructive practices, implementation of efficient water distribution, development of more suitable crops, political and demographic stability, and pragmatic planning.

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The social-economic implications of glacial recession on Mountain Rwenzori, Western Uganda

Yazidhi Bamutaze

Studies addressing the impacts of climate change on the environment in Uganda are largely confined to Mount Rwenzori. Since 1903, the Department of Geography, Makerere University has been monitoring glacial coverage on Mt. Rwenzori. A recent expedition (2003) to mountain Rwenzori has revealed significant changes in the spatial coverage of glaciers due to climate change. It is now projected that the glaciers will be completely lost by 2020. The findings from the expedition have prompted a further look at the socio-economic regional implications of glacial recession to the surrounding communities of Mt. Rwenzori. Although the studies are inconclusive and still at the preliminary stage, it has been realized that the recession of glaciers on Mt. Rwenzori will have significant socio-economic impacts on the livelihood of the Bakonzo and Baamba communities, the indigenous inhabitants of the mountains who depend upon the continued vitality of their local environment and tourism to the snow-capped Mountains. This conclusion is premised on among other things the low levels of adaptability within the region.

ADAPTATION, CLIMATE CHANGE, GLACIAL RECESSON, MT. RWENZORI

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Floral diversity of mangroves in understanding paleoecology during the Holocene in Bengal Basin

Nimai Chandra Barui

Fresh subsurface peat samples were collected from different locations in the city of Calcutta during Metro Railway Project Work and palynologically investigated. Samples were also collected from adjoining areas of Calcutta. Analytical investigation of pollen revealed the existence of a large number of core mangroves associated with peripheral mangroves and some fresh water elements and ferns during 7030 yr BP to the present. The dominant fossil pollen grains recovered from the samples were *Heritiera*, along with *Excoecaria*, *Bruguiera*, *Aveciennia*, *Rhizophora*, *Barringtonia*, *Sonneratia*, *Suaeda*, *Phoenix paludosa*, *Nipa* and a large number of fern spores, such as *Achrostichum* and grass pollen grains reflected variable amounts of vegetation in the three different peat bands. They also reflect the swampy halophytic vegetation, to some extent comparable to the present day vegetation of the Sundarbans.

MANGROVES, DIVERSITY, HOLOCENE,

PALEOECOLOGY, BENGAL BASIN

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Reconstruction and assessment of climate and human impacts on catchment ecosystem from sedimentary records in central Anhui, east China

Xuerong Dai, John Dearing, Lizhong Yu, Weiguo Zhang, John Boyle, Yuxin Shi, Gez Foster

Here, we focus on reconstruction and assessment of climate and human impacts on terrestrial and fluvial ecosystems, within the framework of the NSFC-Royal Society joint research project on "Historical reconstruction of climate and human impacts on the lower Yangtze River, East China". We use a high-resolution sedimentary record from a 20th century reservoir in the densely populated Hangbu River catchment, in central Anhui. Sedimentary cores were taken from Longhekou reservoir, which was built in AD 1958 in the upper reaches of Hangbu River. Among these cores, ALE is the longest one (102 cm) and the only one that reaches the gravel bottom of the reservoir. Laboratory analyses on this core have been conducted, including particle size analysis, magnetic measurements, organic carbon and nitrogen and phosphorus determination, XRF geochemistry. Data from meteorological and hydrological records, social records and satellite images are also obtained. The reservoir has three main tributaries originating from Dabie Mountains and the adjacent cultivated hilly lands, of which Xiaotian delivers nearly 70% of the total water and silt. This makes it possible to correlate the sedimentary records (by using a particle-size proxy) year by year with the hydrological records (runoff) by Xiaotian gauging station. From this we can build a depth-age model since 1958. Multi-proxies indicate that five sharply increasing peaks of sedimentation before 1979, are followed by a decreasing trend in sedimentation. Catchment changes in land use can explain the switch in hydrological regime (Project No. 40271107, 40411130070).

HUMAN ACTIVITY, ENVIRONMENTAL CHANGE, SEDIMENTARY RECORDS, EAST CHINA, HITE

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Paleolimnological perspectives on long-term environmental change in the Canadian High Arctic

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Although lakes and ponds characterize most arctic regions (about 18% of Canada's surface waters are north of 60°N), and are important sentinels of environmental change, very few long-term data are available, and so indirect proxy methods must be used in lieu of these missing data sets. We have been applying both present-day limnological techniques as well as paleolimnological approaches to study long-term environmental change throughout the Canadian Arctic Archipelago (islands north of the Canadian mainland). Our data show that lakes in different settings follow different ecosystem trajectories, dependent on local and regional factors such as geological and climate characteristics. However, it is now becoming increasingly clear that marked limnological changes have been occurring in many arctic lakes and ponds over the last ca. 150 years that appear to be related to climatic warming. These changes are manifested as changes in community composition of the primary (algal) and secondary (e.g., invertebrate) producers. In some extreme cases, usually in the higher latitude sites, complete species turnovers have been documented. Furthermore, as a result of global transport of pollutants and the effects of climate warming, both of which are magnified in polar regions, these lakes and ponds deserve much more attention, as they are critical bellwethers of environmental change. Paleolimnological and archeological data also show how lakes have been affected by human disturbances at much longer timescales, such as nutrient inputs from Thule Inuit whaling camps abandoned centuries ago. We summarize some of our key findings from two decades of paleoecological research in the Canadian High Arctic.

PALEOLIMNOLOGY, ARCTIC, CLIMATE CHANGE, ALGAE, CANADA

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Carbon isotope composition of fossil charcoal as a new paleoenvironmental proxy

Juan Pedro Ferrio, Natàlia Alonso, Joan López, Jose Luis Araus, Jordi Voltas

Although several proxies for the inference of precipitation have been proposed, evidence of changes in aridity during the Holocene is scarce, and most is only qualitative. Moreover, precipitation regimes show relatively poor spatial correlations and can exhibit contrasting responses to global climate trends in different areas. Thus, there is a need to concentrate efforts at the local scale in order to increase the spatial resolution of paleoclimate records, specially regarding water availability in semi-arid zones. Here, we propose the analysis of carbon isotope composition ($\delta^{13}\text{C}$) in fossil charcoal (routinely recovered from archaeological sites) to quantify changes in water availability in the past. We applied this approach to reconstruct variations in aridity during the last four millennia in the Ebro Depression (NE Iberian Peninsula). First, we studied the effect of carbonization over a range of temperatures (300-500°C) on the $\delta^{13}\text{C}$ of Aleppo pine (*Pinus halepensis* Mill.) wood cores, collected from nine locations in NE Iberian Peninsula with distinct water availability. After correcting the effect of carbonization, we estimated annual precipitation (P) and the ratio between annual precipitation and evapotranspiration (P/E) from the $\delta^{13}\text{C}$ of fossil charcoal. In general, estimated water availability in the past was higher than present values, indicating that latter-day (semi-arid) conditions are mostly due to recent climatic changes. The good agreement between our findings and other evidence indicates that the analysis of $\delta^{13}\text{C}$ in charcoal may be useful to expand current paleoclimatic records as it provides a complementary (and quantitative) source of information to assess climate dynamics.

STABLE ISOTOPES, PALEOCLIMATE, LATE HOLOCENE, FOSSIL WOOD, WATER

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Human presence and its impact as recorded in Lake Lavarone (Dolomites, NE Italy) sediment record

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Human presence in middle to high altitude sites in

Trentino (Dolomites, NE Italy) has been documented since the Late Glacial. Lake Lavarone sediment sequence, which is the first, complete Late Glacial to present day record from this region, however, indicates that the environmental impact of humans was almost negligible until the Roman Age. Here, we present a multi-disciplinary study on the topmost part of Lake Lavarone (1100 m asl, 0.05 km² large, 17 m deep) sediment sequence, which covers the last 2000 years, with particular attention to the last 150 years. The occurrence of *Castanea* and *Cerealia* and the high concentration of micro-charcoal at about 2000 yrs BP are considered as indicators of the Roman settling in the area (Roman Imperial Period, I-III sec. AD). The onset of the medieval period is marked by arboreal pollen decrease (from 90-70%), micro-charcoal concentration increase (from 10,000-30,000 particles/cm³) and anthropogenic indicators (ca. 10%), such as *Cannabis*. Sedimentology, physical proprieties, mineralogical and geochemical data, together with algal distribution changes, indicate important variations in Lake Lavarone hydrology dated to the Early Middle Ages. In the last century, diatoms distribution clearly shows significant changes in the lake trophic status, with a peak of eutrophication at the end of the 1960s, and a subsequent slight tendency to lake recovering to lower trophic level. Ongoing geochemical analyses on metals will help to highlight the impact of human industrial activities.

HUMAN IMPACT, PALEOLIMNOLOGY, HISTORICAL TIME, EUTROPHICATION

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The Younger Dryas in the Italian Alps: Climate and cultural evolution

Silvia Frisia, Giampaolo Dalmeri, Christoph Spötl, Andrea Borsato, Mizzi Filippi

The discovery of Late Paleolithic (ca. 13.000 yrs BP), excellently preserved painted stones in the Dalmeri rock shelter (ca. 1300 m asl) in the Alps of Italy, with stylistic echoes of French-Cantabrian art, provides a unique testimony of pre-Younger Dryas (YD) cultural evolution. After the YD, the Mesolithic hunter-gatherer lifestyle indicates a connection with North European populations. A stalagmite (SV1) stable isotope record from Grotta Saviin NE Italy reveals evidence of climate instability between 17.0 to 12.0 kyr BP. Since 11.0 kyr BP, isotope series show less intense fluctuations. In SV1,

the YD (12.0 and 11.4 kyr BP) is characterized by high ¹⁸O values, coinciding with ¹³C enrichment of up to +1‰. The extension rate of the stalagmite during this interval is the lowest (<8 µm/year) during the past 16.0 kyr. We infer that the YD was cool and relatively dry, with short warm seasons. Near the Dalmeri Shelter, lake sediments and their pollen content support the hypothesis that during the YD mid-high altitude Alpine environments were deglaciated, thus allowing cultural exchange with northern Europe. Geological and archaeological data suggest that Alpine Paleolithic art was a response to Pre-Holocene climate instability, which required deep knowledge of the environment, as already hypothesized by Mithen (2003). The relatively stable Holocene climate did not require a similarly deep knowledge. In agreement with Mithen (2003) we infer that the YD was the harbinger of the western modern mind.

ENVIRONMENT CHANGE, DEGLACIATION, CLIMATE, CULTURE, PALEOLITHIC

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Human impacts on a Holocene inland wetland (Las Tablas de Daimiel National Park, central Spain)

José Gil-García, Blanca Ruiz Zapata, Juan I. Santiesteban, Rosa Mediavilla, Enrique López-Pamo, Fernando Domínguez-Castro, Cristino Dabrio

The Las Tablas de Daimiel National Park in central Spain is one of the scarce freshwater wetlands still preserved in southern Europe. This system is very sensitive to changes in climate but the sedimentary record also reveals environmental changes due to human activity since around the 10th century AD. The combination of geochemical and pollen data allow us to reconstruct the main environmental and ecological changes. The record shows the transition from a saline prairie to a wet meadow and eventually to a freshwater wetland. An increase in rainfall was probably the reason for a decrease in salinity of waters and soil that allowed the development of hydrophytes, a type of vegetation that requires higher water levels. Finally, the pollen record shows changes in vegetation evolution: arboreal pollen decrease abruptly during the 10th century, followed by a progressive increase in *Pinus* and *Artemisia*. From the late 17th until the 19th centuries, vegetation changes were very frequent and with higher amplitudes. Finally, since the end of the 19th century, the vegetation

changes are interpreted to reflect man-made changes of the environment such as water overexploitation and soil degradation. Regeneration measures for this area have taken place since the late 1980s.

CLIMATIC CHANGES, POLLEN, HUMAN ACTIVITY

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The impact of last interglacial and last glacial maximum vegetation changes on the Australian monsoon

Paul Hesse, Andy Pitman

The potential impact of large scale vegetation changes on the Australian monsoon during the last interglacial and last glacial maximum are explored. We use the Regional Atmospheric Modelling Systems (RAMS) at a grid resolution of ~50 km forced by fixed sea surface temperatures. This model produces an excellent monsoon rainfall pattern and wind field over northern Australia. The control simulation uses present vegetation, simplified to be mainly sparse forest in the north and grasslands further south. In the last interglacial simulation, vegetation is replaced by dense woodland in the north and sparse woodland in the south. In the last glacial maximum simulation, grassland covers the northern areas and semi-desert exists further south. An ensemble of seven simulations for each time period is performed to ensure that results due to vegetation change can be identified above noise associated with the monsoon system. We find a substantial impact of the vegetation change on temperature and the latent heat flux (evaporation). We find no significant impact on the rainfall over northern Australia (changes were limited to ~5% of the control simulation). However, there were substantial impacts on the monsoonal flow associated with the vegetation changes as a result of changes in the aerodynamic roughness. These were weakening/strengthening of the winds - not a change in direction. We therefore find no evidence in our simulations of a strong vegetation feedback affecting the Australian monsoon and we find no suggestion of a link between changes in vegetation patterns north of 23°S and climate changes south of 23°S.

VEGETATION, CLIMATE, MONSOON, AUSTRALIA

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Forest clearance and its impact on fluvial environments in the last 100 years in the Tokachi Plain, northern Japan

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The northernmost island of Japan is well known as the region where deforestation and agricultural land use had drastically progressed only since last 100 years. How had the fluvial processes responded to the drastic change? On the basis of the sediments facies, chronostratigraphy using ¹³⁷Cs, marker tephra, tree ring and the monitoring data of present flooding and so on, we will examine the change of fluvial environments, sensibility to changes and sustainable development, etc. Major knowledge is as follows: 1. Topographic maps show the timing from the natural forest to agricultural land in each drainage basin particularly in term of the intensity. 2. Fluvial sediments after the forest clearance are significantly coarser, comparing with those of the pre-deforestation. 3. The timing of grain size change of sediments has clearly coincided with the deforestation in each drainage basin. This fact implies that the fluvial processes immediately respond to the human environmental disturbance. 4. The ¹³⁷Cs analysis showing the horizon of sedimentation in 1963 make us possible to evaluate the recent accelerated sedimentation rate. 5. Monitoring of river water level and rainfall from 2000 to 2002 recorded the over bank flooding 4 times, when the total amount of rainfall attained to ca. 100 mm or more. 6. Suspension load during the over bank flooding contains the coarse particles composing the over bank sediments since the beginning of forest clearance.

HOKKAIDO, FOREST CLEARANCE, FLUVIAL SEDIMENTS, RESPONSE TO FLUVIAL SYSTEMS, ¹³⁷Cs

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Holocene colluviation in response to monsoonal climatic change and human impact on the loess lands in the Weihe River Valley, Northern China

Chun Chang Huang

Colluvial components incorporated in loess-soil sequences have preserved evidence of soil erosion

and redeposition in the middle reaches of the Yellow River drainage basin. Holocene loess-soil sequences were studied by measurement including magnetic susceptibility and particle-size distribution, and extraction and identification of the non-dust materials. The analytical results indicate that soil erosion and redeposition by overland flow occurred on the gently sloped loess land in the early Holocene in response to climatic amelioration linked to global climatic change. No obvious soil erosion and redeposition events were found to correspond with the climatic fluctuations recorded in the loess-soil sequence during the Holocene Climatic Optimum. The primary Neolithic farming did not cause apparent erosion and redeposition because the loess landscape was mantled by well-developed Cinnamon soil and forest vegetation, providing adequate resistance to sheet erosion by overland flow. Enhanced soil erosion and redeposition are traceable back to ca. 4000 yr BP. It is attributed to intensified land-use of arable farming and human settlement from the early Bronze Age onward. A major event of sheet erosion and redeposition by overland flow occurred during 4000-3600 yr BP in the Xia Dynasty. Climatic aridity and intensified dust accumulation may have played a secondary role in promoting soil erosion since 3100 yr BP. These results provide new insights into the history of soil erosion in the semi-arid and semi-humid loess regions and into the evaluation of human-induced accelerated soil erosion against the background of the Holocene natural erosion forced by monsoonal climatic fluctuation.

COLLUVIATION, HOLOCENE, SOIL EROSION, HUMAN IMPACT, CHINA

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Changes in soil forming environment studied in a tephra-soil sequence on ignimbrite plateau of southern Kyushu, Japan

Yudzuru Inoue

Sixty-nine soil and tephra samples were collected from a profile containing 8 humic horizons and 10 identified tephra on Miyakonojo ignimbrite plateau in southern Kyushu, Japan. The ages of identified tephra layers were obtained as ca. 26, 12.8, 8.0, 7.6, 7.3, 6.4, 4.6 cal ka BP by ^{14}C dating, and AD 1235, 1471, 1914 by historical records. Quartz contents, clay mineral composition, organic carbon and nitrogen contents, phytolith composition, and stable nitrogen isotope ratio were examined to interpret past soil forming environment from late Pleistocene to present. The mineral composition of the lower part of Brown loam layer, the bottom most layer in the profile, was characterized by abundant quartz in sand fractions and halloysite accompanied with 1.4 nm, micaceous and kaoline minerals, which assigned the deposit of tephric loess; the secondary eolian deposit

of ignimbrite. While the upper part of Brown loam layer characterized by rich quartz in silt fraction indicated the influence of long-range eolian dust. Opal phytolith analysis revealed the variance of dominant grass species; Phragmites, Sasa (excluding Miyakozasa), Miscanthus, and Pleioblastus sect. (Medake and Nezasa), which assigned the fluctuation of source organic matter in soils from late Pleistocene to Holocene. The $\delta^{15}\text{N}$ values in the tephra and soils partly revealed as responses of soil moisture condition to climate change. The low $\delta^{15}\text{N}$ values (minimum; 2.9‰) in some humus horizons including pumice, suggested the possibility of nitrogen accumulation caused by atmospheric nitrogen fixation with climate warming.

SOIL-FORMING, TEPHRA, OPAL PHYTOLITHS, $\delta^{15}\text{N}$, TEPHRIC LOESS

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Water management and the demise of ancient civilizations - Case study of the Classic Maya and contemporary Sahel using a drought aspect in a management perspective

Joakim Isaksson

Here, I analyze two regions, the Ancient Classic Maya and the present western Sahel, focusing on drought and adaptive management in both regions. They both share some biophysical and climatic conditions, and both have had drought problems affecting their societies more or less. I examine whether or not we can learn about adaptations to droughts from the Ancient Classic Maya to use in ecosystem management in the Sahel of today. I look at a set of conditions in the areas; climatic, socially and ecologically. I found that, in a complex society such as the Ancient Classic Maya, the institutional connections and the power holders are vital for a functioning society in times of crisis. There must be both a buffer built in to the systems, as well as a set organization to handle changes and difficulties in a society. This could be of interest also for present-day western Sahel and I make both general and specific recommendations as to what is necessary for the region to co-develop with its changing environment.

DROUGHT, WATER MANAGEMENT, SAHEL, ADAPTIVE CAPACITY

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Decoupling the influences of climate and people on notable transformations of the Australian landscape

Peter Kershaw, Chris Turney, John Tibby, Sue Rule, Aline Philibert, Chris White, Patrick Moss, Heather Builth

Two major debates, related to the timing and causes landscape change around the time of human arrival in the late Pleistocene and to the nature and causes of a proposed increase in 'intensification' of human occupation within the late Holocene, have plagued researchers within Australia for many years. Central to both debates is an elucidation of the impacts of people and climate. In order to try and resolve the debates, two paleoecological records have been examined. For the earlier event, a refined record through the last 50,000 years was produced from Lynch's Crater in northeastern Queensland, a site that has long demonstrated rainforest destruction in association with increased burning around the time of human arrival. This record indicates marked variation in selected attributes at millennial and orbital scales that can be attributed to systematic changes in the activity of the El Niño-Southern Oscillation (ENSO). Significantly, the increase in burning (45,000 years ago) precedes forest destruction that only occurs with the onset of a precessionally-induced phase of high El Niño several thousand years later. Consequently, it is proposed that the arrival of people had little influence on the landscape until their impact was combined with that climate. For the later event, rates of change analyses were undertaken on components of a record from southeastern Australia. The evidence for marked and synchronous rate increases in both dryland pollen and aquatic diatom components about 4000 years ago is considered to indicate an underlying climate cause, most likely another phase of high ENSO activity.

PALEOECOLOGY, CLIMATE CHANGE, HUMAN IMPACT, EL NIÑO-SOUTHERN OSCILLATION, RATES OF CHANGE ANALYSIS

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The effect of local climate change on the Harappan port of Lothal (4300-3500 cal yr BP), Gujarat, western India

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The cause of past civilization collapse has commonly been attributed to global climate change, suggesting a climate-culture causal relationship. However, not all agree to such a viewpoint, primarily because technologically sophisticated civilizations may indeed be resilient or may adapt to adverse environmental conditions. The present study represents a paradigm shift in approaching this problem. Rather than documenting global climate change, efforts were made to document local climate change proximal to a port town of the Harappan civilization, Lothal, in western India. In order to reconstruct the paleoclimatic record, environmental magnetism, infrared spectroscopy and microfossils were used to identify significant events of abrupt climate change. On comparison of the paleoclimatic record with the occupation history of Lothal, it is observed that the collapse of Lothal coincides with a mega-drought event ca. 3500 cal yr BP. A minor drought episode about 4000 cal yr BP is also seen as a boundary between two major occupation phases of Lothal. This study, if replicated at all the towns/cities that comprise the Harappan civilization (e.g., Dholavira, Harappa, Mohenjo Daro) should decisively resolve the climate-culture controversy. Here, it is concluded that a causal relationship does exist between the local climate and occupation history of Lothal.

HOLOCENE, HARAPPA, CIVILIZATION, MONSOON, GUJARAT

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A continuous and high-resolution Holocene climate-proxy record from the hyper-arid central Sahara Desert (Ounianga Kebir, NE Chad)

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We report here the recovery of a finely laminated sediment record from Lake Yoa, a 25 m deep hypersaline lake at Ounianga Kebir in remote northeastern Chad (19.0°N; 20.5°E). Lake Yoa is one of the very

few permanent waters in the hyper-arid central Sahara desert, where rainfall is negligible and annual evaporation exceeds 600 cm. Today it is maintained by subsurface inflow of fossil groundwater from sandstone aquifers recharged during the early-Holocene humid period. The 7.7-m long sediment profile reveals continuous mm-thin lamination with sub-annual resolution. It represents the first, and most probably only, continuous record of climate and environmental change for the arid-sub-arid belt of North Africa from the lower Holocene to the present-day. Preliminary sedimentological, chronological, fossil-diatom and chironomid data from the upper 3.7 m suggest that Lake Yoa has been poly- to hyper-saline during the past 2600 ¹⁴C years, and that conditions of physical and chemical limnology have been similar to today for the past 1000 years. Ongoing analyses and AMS dating will fill the gap in our knowledge of climate history of the Sahara due to lack of high-quality sedimentary archives since its desiccation about 3000 years ago. The core's lower parts can potentially be correlated with laminated early-Holocene lake beds that are exposed in neighboring Ounianga Serir up to 80 m above the present-day lake level. The anticipated results will significantly improve the existing data on the early and middle Holocene of the central and eastern Sahara and help to better understand the archeological evidence.

SAHARA, PALEOCLIMATE, HIGH RESOLUTION, HOLOCENE, OUNIANGA

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Separating climatic and human impacts in the early Holocene: Biotic response around the time of the 8200 cal yr BP event

Peter Langdon, Kevin Edwards

The early Holocene is characterized by rapid climate change events, which in the North Atlantic region are often associated with changes in thermohaline circulation. Superimposed on this in NW Europe is localized evidence for human impact on the landscape, although separating climatic and anthropogenic mechanisms for environmental change is often difficult. Biotic and sedimentological evidence from a lacustrine sequence from the Inner

Hebrides, Scotland, shows a considerable reduction in inferred local woodland centered upon 8250 cal yr BP. These data correlate precisely with a distinctive rise in the charcoal:pollen ratio and hence suggest Mesolithic human impact upon the vegetation around this time. A quantitative temperature reconstruction from chironomid analyses from the same sequence, supported by sedimentological data, indicates that the fall in arboreal pollen taxa occurred as climate warmed significantly during the early Holocene. This warming was followed by a significant cold event, with mean July temperatures reduced by 2°C, that lasted for at least 320 years ca. 7790-7470 cal yr BP. Woodland recovered during this phase suggesting that the vegetation is likely to have been responding to human activity, and not climate, and hence it is possible at specific sites to separate the influence of these key drivers of environmental change.

8200 CAL YR BP EVENT, CLIMATE CHANGE, SCOTLAND, CHIRONOMIDS, POLLEN

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Reconstructing the past to understand the present and forecast the future

Dagnachew Legesse

The reconstruction of environment and climate changes over the past few centuries is essential to understand the impact of natural processes and human activities on the ecosystems, and to forecast their evolution in the near future. This is especially relevant in semi-arid regions of the African tropics. Here, the variability in lake water depth and chemistry was studied on the main Ethiopian rift valley lakes using: multi-proxy analysis of short sediment cores, a modeling approach was developed to understand the natural variability as well as propose different scenarios for the future. The multi-proxy record provides evidence for large fluctuations in water depth and salinity as well as changes in vegetation cover in the basin, which can be tentatively compared with instrumental and historical records. From our investigation one of the studied lake, Lake Abiyata proved to be a suitable site for a detailed reconstruction of climate fluctuations over the recent past in the Ethiopian Rift and surrounding highlands and to analyze human impact on the lake system. Integrated dynamic water and chloride balance models with a catchment-scale hydrological model (PRMS) are used to investigate the response of the lakes to climate variability and water use practices in the catchment. The results are integrated with the multi-proxy record to reconstruct the past and predict the future. This approach can be adapted in other parts of the region undergoing similar environmental and climatic changes. It can

also provide a better way to manage the fragile rift lake ecosystem in a sustainable manner.

ENVIRONMENTAL RECONSTRUCTION, MULTI-PROXY, CLIMATE CHANGE, MODELING, LAKES

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Soil amino sugars: a potential tool for characterizing long-term land-use changes

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Soils hold unique information that may be used to assess the relative impacts of human activity and natural climate variability. This is because changes in soil property may be caused by climate variability and/or human-induced land-use changes. However, to retrieve evidence from soils for decoding the differing effects of the two controls is highly challenging, particularly on a long-term timescale. Here, we present a preliminary study on a biochemical marker: amino sugars in soils and their potential in the study of past land-use changes. Soil amino sugars are mostly of microbial origin. As microbes play an important role in the complex processes of soil organic matter dynamics, it is hoped that the variations in amino sugars may be used to characterize the long-term land-use change. In this study, soil samples from 13 grassland sites with semi-humid to semi-arid climate in the western Liaohe River Basin of Inner Mongolia, China were collected. In addition to the C/N measurements and pollen analysis of the soil samples, glucosamine, mannosamine, galactosamine, and muramic acid were determined by gas chromatography. The soil amino sugar content varies markedly from 174 to 3201 $\mu\text{g/g}$ among the 13 sites. It increases significantly along a rising annual precipitation gradient (300-484 mm) but with decreasing annual temperature (3.0-7.2°C). The amino sugars in three particle-size fractions were determined. Unlike previous studies, silt-sand fractions in our samples show closer correlation with climate variables than the clay fractions. A comparison of soil amino sugars with pedochemical, magnetic and palynological data will also be presented.

SOIL, LAND-USE, AMINO SUGAR, CHINA

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Variability in recent sedimentation rates and its implication of human activity: Ise Bay, Japan

Xueqiang Lu, Eiji Matsumoto

Ten sediment cores were collected from Ise Bay, Japan, and excess ^{210}Pb and ^{137}Cs were measured gamma-spectrometrically. Using the constant flux of ^{210}Pb (CFL) model, the temporal and spatial variations of sedimentation rates in Ise Bay were determined. An overall increasing trend in sedimentation rate over the last century, especially since the mid-20th century, was found at all of the locations. The increase in sedimentation rate since the mid-20th century is consistent with the rapid economic growth and corresponding intensification of environmental alteration. The spatial distribution of sedimentation rates is time-independent. The high sedimentation rates were found near the mouth of the Kiso River, indicating that river input is a main source of sediment. The sedimentation rates in the eastern half of the bay are higher than those in the western half, reflecting the transport pathway of suspended matter. The mean sedimentation rates over the last 40 years derived from both ^{210}Pb and ^{137}Cs methods were roughly consistent. The inventories of excess ^{210}Pb and ^{137}Cs in sediment are accounted for by the direct atmospheric fluxes, except a core near the river mouth.

SEDIMENTATION RATE, LEAD-210, CESIUM-137, HUMAN ACTIVITY, ISE BAY

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Research on extreme floods since 5000 yr BP recorded in an archeological site in the Three Gorges area

Chunmei Ma, Cheng Zhu, Huizhong Chen, Chaogui Zheng, Zhibin Sun

Based on the field investigation of geology and geomorphology and the analysis to the AMS ^{14}C dating, grain size, geochemistry elements, and magnetic susceptibility from deposits of the excavation unit T0102 of the Neolithic Site named Zhongba in the Three Gorges area, combined with archaeological data and historical materials, we reveal that the site archives at least ten extreme floods, that is, two (about 3000 BC to 2500 BC) during the late Neolithic period, one (about 2000 BC) during initial stages of Xia Dynasty, two (about 1000 to 800 BC) during the west Zhou Dynasty, one (about 400 BC) during the early days of Warring States, two (AD 1153 and 1127) during the Song Dynasty, one (AD 1870) during the Qing Dynasty and one (AD 1981) in the modern

times. With low magnetic susceptibility values and high $(\text{Fe}+\text{Al}+\text{Mn}+\text{Cr}+\text{Co}+\text{Ni})/(\text{K}+\text{Na}+\text{Ca}+\text{Mg}+\text{Sr}+\text{Ba})$, Mg/Ca and Rb/Sr values compared to the sediments of the cultural layers, the flood sediments show the character of slack water deposit from analysis of grain size. Our analysis to the profile and regional contrast indicates that, on one hand, these extreme floods are related to heavy precipitation because of corresponding strong monsoon, most of which happened during the periods of climate fluctuating or transformation, on the other hand, human economic activities such as salt production in this region led to the great loss of soil and water, which intensified the flood disasters.

ZHONGBA SITE, GRAIN SIZE, MAGNETIC SUSCEPTIBILITY, GEOCHEMISTRY ELEMENT RATIOS, EXTREME FLOODS

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Ecosystem degradation of Lake Naivasha, Kenya: Proposals for sustainability

Edward Mulaama

Dust deposition analysis indicates that, periods of major droughts around Lake Naivasha caused severe consequences for the local human societies. This study also finds that the quality and quantity of the water, the amount of tilapia fish being harvested have been steadily decreasing putting the survival of the lake organisms and the local human communities at risk. The fish being caught in the lake have deformed bodies of distended bellies, which make them easy prey for predators. The rising human population around the lake leads to over-fishing and contamination of the lake thus ruining their own economic prospects. Since 1998, new predators like cormorants, eagles and pelicans have arisen that consume fish much faster than the population can replenish. Analysis of the lake sediments indicates that ancient intercultural conflicts led to human migrations or death of people who could work on farms, hunt for game or gather fruits and nuts and hurt the farm labor and begun the economic degradation of the Lake Naivasha area. Starvation forced the humans to eat new foods and animals like giant rats, mollusks and reptiles that have high levels of worms and toxicity in their bodies. These contributed to the rapid demise of those communities. Archeological analysis of sediments from Lake Naivasha, nearby rivers and quarries indicate that the collapse of such communities coincided with abrupt changes in the environment and climate change. The author proposes ways to replenish stock and sustain

the human activities around Lake Naivasha where human survival is threatened.

DUST DEPOSITION, TILAPIA, DEGRADATION, POPULATION, SEDIMENTS

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Relationship between landform process and reed distribution

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Intensive agricultural development since the 1950s has drastically changed the landform of the Toberi River basin located in the southern Tokachi Plain in Hokkaido, Japan, which had been covered by natural vegetation until the settlement in the late 19th century. As a result of this impact, soil production in the river has increased rapidly and the natural levee has established in the lowermost reach of the river. Populations of the reed, *Phragmites australis*, a well-known wetland plant, are patchily distributed throughout the basin. In this study, in order to investigate the effect of sediment transportation on the formation and distribution of reed populations, genetic variations among reeds in the basin were analyzed using isozyme makers. Among 31 populations examined, the UPGMA dendrogram based on Nei's genetic distance showed genetic similarity between the reed populations of lowermost wetland and those of the two tributaries, suggesting the gene flow from the tributaries to the lowermost wetland occurred due to long term landform processes. Interestingly, a specific genotype (type IV of PGI-2 locus) found in the clone on the natural levee also exists in the clones on the overhanging cliff of one tributary where the sediment supply is currently abundant. This suggests that reeds on the levee were drifted from the anticipated upstream population. From these results, it is concluded that the reed distribution depends on the landform processes. In particular, present rapid changes in landform caused by human impacts were reflected in the reed distribution.

HUMAN IMPACTS, SEDIMENT TRANSPORTATION, LANDFORM PROCESSES, PHRAGMITES AUSTRALIS, GENETIC VARIATION

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Integration of remote sensing and GIS to assess human impact on ecosystem change in Nyando River basin (Kenya)

Lydia Olaka

The demand on available resources has significantly altered our environment. Studies concerning the anthropogenic impact on the environment (particularly land cover change) in Lake Victoria basin are in their infancy. This is due in part to limited access on collection of data. GIS and remote sensing are important in analysis, interpretation and extrapolation. This study analyses the process of human induced landscape transformation on Nyando River basin (3517 km²) in the Lake Victoria basin. The study area has been identified as a major source of sediment and nutrient flow into the lake. The watershed geomorphology comprises; hills, scarps, plateaus and a plain area with different types of erosional features; The spatial and temporal change patterns of land use were quantified by interpreting remote Sensing (RS) data and used a geographical information system (GIS). Landsat images (1973 and 2000) were used to classify the catchment into five land use classes: bare ground, water body, agricultural land, dense forest and sparse forest using supervised classification in ENVI. During the last 32 years, the vegetal cover was altered drastically with increasing population pressure (both human and animal), agricultural activities and wood extraction, results have shown that the area covered by dense forest has reduced while the area covered by sparse forests, agricultural land and likewise bare ground (which includes eroded areas) has increased. Erosional features; rills, badlands and gullies have also increased significantly. The future of the environments depends on the way we use them now.

LAND USE CHANGE, HUMAN IMPACT, EROSION, REMOTE SENSING, GIS

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The evolution of valley floors and ancient societies adaptation to natural constraints: A geoarcheological approach from the Majerda catchment (North Tunisia)

Ameur Oueslati

The Majerda is the most important stream of Tunisia draining almost an eighth of the country surface. In antiquity, especially during Roman occupation, it was heavily exploited and had supplied Rome with cereals for a long time. For this reason it is often designated by historians as the granary of Rome. The examination of the morphology of the lower parts of valleys and the numerous archeological structures associated with them or situated in their proximity helps to reconstitute the main tendencies of the natural environment dynamics since classical antiquity. It also offers good opportunities

for developing a precise stratigraphy of the continental historical deposits and forms. The archeological artifacts permit, in some cases, a chronology more precise than that based on radiometric methods. It was possible, in this first stage of our research, to identify evidence of an alternating dynamics favorable for alluviation or for incision. Beyond its stratigraphical purpose, we aim to disengage the main tendencies of the environment evolution during the last two thousand years. Here, we also try to bring some new data permitting a better definition of the respective place of man and natural components, mainly climate, in this evolution. Some archeological sites offer, in addition, the possibility, considering the nature of their structures and their position in comparison with the oueds (wadis), to measure the adaptation of ancient societies to their environment and especially to natural hazards. This can, in some cases, bring instructive analogies for present managements.

GEOARCHAEOLOGY, LANDSCAPE EVOLUTION, ANCIENT SOCIETIES, MANAGEMENT, ENVIRONMENT

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Development of human societies as related to environmental changes using pollen data from archaeological sites in the Middle Urals (Russia)

Nata K. Panova

Peat-bog lake sediments adjacent to excavated ancient human insular settlements of the Neolithic and Bronze ages were pollen-analyzed. Pollen evidence from 5 examined sequences in the Middle Urals allowed us to distinguish 3 main stages of vegetation development and the whole nature environment: 1. Sapropel layers were formed when water pools were developed, surrounded by most rich vegetation: pine-and-birch forests with spruce dominating, added with fir, basswood, elm, oak, hazel and even rare Carpinus; climate was warm and humid, corresponding to the Atlantic period. 2. Pollen of transitional layers, between sapropel and peat-bog strata, evidenced of the process of lakes' filling up by vegetation, whereas terrestrial vegetation turned poorer (no nemoral components), climate becoming cooler and more arid. 3. Pollen spectra from peat-bog samples indicating vegetation of sphagnum-and sedge bogs surrounded with pine forests with birch and spruce, climate conditions being similar to nowadays. Radiocarbon dates and artifacts dated to 6000-4000 years BP, found in transitional layers, allow us to conclude that paludification of water pools occurred during the Sub-Boreal time. The associated artifacts showed that during the Neolithic and Eneolithic, fishery and hunting were the main occupations of people, and peat formation made people leave their bank settlements. Later on at the boundary of Eneolithic and Bronze ages, worsening of climate conditions and natural biodiversity decrease

provoked the people to change their main type of activities, towards developing producing economy types. Human-made load on vegetation at that period was minimal.

POLLEN ANALYSES, PEAT BOG, SAPROPEL, ARCHEOLOGICAL SITES, VEGETATION & ENVIRONMENTAL HISTORY

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Millennial analysis of reconstructed climate in the Carpathian Basin on the basis of coded written sources

Rita Pongracz, Judit Bartholy

Written sources can be used to evaluate the occurrence and duration of past climate events where there is a lack of, or only scarce, instrumental time series. For the Carpathian Basin (located in Central/Eastern Europe), Antal Rethly collected historical documents containing meteorologically related information into a 2500-page-long book series titled 'Meteorological Events and Natural Disasters in the Carpathian Basin'. In order to facilitate the detailed analysis of this documentary collection, a special code system using hierarchical subclasses has been defined. Three main categories of climate information have been distinguished: temperature, precipitation, and wind related events, containing about 3800, 10000, and 1300 information items, and classified into 14, 32, and 15 groups, respectively. Among the temperature related documents, reports on cold conditions dominate (65%), while in case of wind most of the archive records mention the strength. Precipitation information takes 66% of the total collection and the most often reported event is the 'rain', which can be explained by the source types (many estate records and account rolls) and by the agricultural importance of water. Other frequent classes of precipitation are 'thunderstorm', 'hail', 'flood', and 'drought'. Besides the event classification, the coded database contains full geographical information about the location of the meteorological events (settlement, geographical coordinates, and subregion identification). Spatial and temporal distribution of precipitation, temperature, and wind related climate events have been investigated using both settlement and subregional scales. Decadal, annual, and seasonal reconstructed time series have been analyzed for the Carpathian Basin region.

HISTORICAL WRITTEN SOURCES, RETHLY'S COLLECTION, TIME SERIES RECONSTRUCTION, CARPATHIAN BASIN

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Human-environment interactions in a coastal lake, India: Past and present

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Lake ecosystems in India have been modified significantly in the recent past by both natural and human influences. The Pulicat Lake on the southeast coast of India is the second largest brackish water lake, spreading over 460 km². Acute drought conditions have considerably reduced freshwater inflow and increased siltation of the lake, thereby resulting in hyper-salinity, reduced fishery resources and hypoxic conditions in many parts of the lake. Frequent closure of the bar mouth has caused inaccessibility for fishermen to reach the adjacent sea (Bay of Bengal) and has also restricted the movement of marine fishes into the lake for breeding. Eight one-meter sediment cores collected from the coastal Pulicat Lake across various transects were subjected to radiometric dating to determine modern sedimentation rates in these ecosystems. Our results indicate that the Pulicat Lake yields an average sediment accumulation rate of 12.34 mm/yr. In general high rates of sedimentation observed in coastal ecosystems not only reflect the capacity of coastal regions as sinks for trace metals but also denote increased input of pollutants into coastal environments in the recent past. The deposition rates of heavy metals—Fe, Mn, Zn, Cu, Cr and Ni—in the depth profiles have been computed using sedimentation rates and their distribution is discussed. It has been observed that the mean deposition rate of all the measured elements in the Pulicat Lake are high compared with rates determined for sediments of the deltaic regions of India and the Bay of Bengal.

LAKE, SEDIMENTATION RATE, HUMAN INFLUENCE, METAL ACCUMULATION

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A diatom record of decadal resolution of limnological and climatic changes at Ribains Maar (French Massif Central) during the Eemian and early Late-Glacial periods

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Ribains Maar, which is one of the few sites in France that provides a detailed record of the Eemian interglacial, was first studied by Beaulieu and Reille (1992), who established a chrono-stratigraphy for this sequence based on pollen analysis. More recently a multiproxy study was carried out, that combined the analyses of diatom assemblages, oxygen isotopes in diatom silica

and the results obtained from a pollen-climate transfer function. In the present study, the results of diatom analyses are re-examined using both qualitative and quantitative approaches in order to achieve a more detailed interpretation of the limnological changes that occurred during the Eemian and the early Late Glacial periods. The qualitative approach uses the auto-ecological information on the main diatom species. The quantitative approach consists of using a very large training set of modern surface sediment diatom samples and associated environmental data that was developed within the framework of the European project EDDI (<http://craticula.ncl.ac.uk.uk/Eddi/>) to develop transfer functions and reconstruct key climate-driven limnological variables (nutrients, pH, water depth) from the fossil assemblages of Ribains Maar. In this study, we also attempt to assess how much the diatom flora was affected by climate change directly and indirectly, through catchment-mediated processes, by using multivariate statistical analyses on the diatom and pollen data. Finally, possible links between the peaks in abundance of some indicator diatom species and the orbitally-driven fluctuations in insolation are considered.

EEMIAN, DIATOMS, POLLEN, TRANSFER FUNCTIONS, CLIMATE RECONSTRUCTION

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Late Holocene landscape disturbance and recovery: An East Mediterranean case study

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Past episodes of human landscape transformation and abandonment can provide valuable "experiments" in how degraded landscapes recover, what state they return to, and what controls the recovery process. Multi-disciplinary field research in Turkey, including systematic archaeological surveys around Sagalassos and other sites, shows that settlement density

reached a maximum during the Hellenistic-Roman-Early Byzantine era (334 BC to ~AD 680), followed by widespread landscape abandonment associated with Arab incursions from the 7th century AD. This HRB cultural period is well marked in pollen records in the form of the Beysehir Occupation Phase. At Nar Lake, coupled high-resolution pollen and stable isotope analyses allow the relationship between middle Byzantine cultural "collapse" and climate change to be critically evaluated. While there is close correspondence between the dates for the end of the HRB and BO phases, this is not true for the timing of the onset of the cultural landscape period. Palynology indicates large-scale human landscape transformation starting from 1200-600 BC, whereas this Iron Age period has low archaeological visibility. This difference may be linked to site loss through erosion/burial; e.g., at Gravgaz there was rapid stripping of limestone soils during the 8th century BC, while alluvial histories further downstream show a shift from bedrock to topsoil erosion. Erosional responses were thus more heterogeneous than either land use or settlement, because of spatial variations in bedrock lithology and soil erodibility. Because of intervening non-reversible ecosystem changes, notably soil loss, pre-disturbance landscape states may not represent appropriate future restoration targets in the Mediterranean.

MEDITERRANEAN, LANDSCAPE, ARCHEOLOGY, EROSION, POLLEN

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The York Institute of Tropical Ecosystem Dynamics (KITE): Change in the vegetation of the Southern Arc Mountains of Kenya as a result of extensive burning

Stephen M. Rucina, Rob Marchant, Henry Hooghiemstra

The York Institute of Tropical Ecosystem Dynamics (KITE) is a new EU funded project that will combine paleoecology, ecology and bioclimatic modeling to explore past, present and future ecosystem dynamics from a number of sites in Kenya and Tanzania, an area that encompasses one of the world's top hotspots of plant and animal biodiversity. KITE will combine, hitherto separate, but complimentary research strands, to work between the traditional borders of distinct research communities. Results will be used to test modeling studies and develop biogeographical theory at a range of spatial and temporal scales. The research outcomes will improve the prospect for forecasting impacts of climate variability on ecosystem functioning and will lead to an increased scientific understanding regarding conservation and climate change. Assessing the role that humans have played in shaping ecosystems over the late Holocene is a crucial element to the project. The Eastern Arc Mountains of East Africa have experienced human impact throughout but particularly over the last 2,000 years, although the timing and location of this is relatively unknown. The presence of Iron Age sites in the Eastern Arc Mountains indicates that these forests have been altered over a long time and what we see today is mostly secondary forests. There is evidence of the presence of original forest remnants at different elevations that indicates these mountains were forested before the human occupation. New evidence will be obtained from charcoal, phytolith, fungal spore and pollen records from numerous locations throughout the Eastern Arc Mountains. Preliminary results from a 6.5-m-core recovered from Ngulu swamp in the northern extent of the Mountains at elevation 860 m indicates that burning was rampant in and around the swamp. The high charcoal accumulation in the core is indeed an indicator of past fire occurrence. The preliminary pollen data show the presence of high herbaceous taxa such as the Amaranthaceae/Chenopodiaceae; a further indicator of disturbance.

EASTERN ARC MOUNTAINS, POLLEN, HUMAN IMPACT, CHARCOAL

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Rainfall variability during the 20th century and its impact on agriculture in the Chhattisgarh State of Eastern India

Annavarapu Sastri

Chhattisgarh State in Eastern India is traditionally an agrarian state with rice as the major crop. About 80% of the area is under purely rainfed conditions. Only 20% is irrigated and even then, irrigation time and amount are dependent on the rainfall in the catchment area of the minor and medium reservoirs. Rice is grown under the broadcast beushening method of cultivation, which is a very typical method of rice cultivation prevailing in only some parts of Eastern India. An analysis of the rainfall from 1901 to 2000 at 60 locations was carried out. It was found that the rainfall shows a significantly decreasing trend in some pockets. The causes of this trend were assessed. Farmers construct huge bunds in rice fields. The field water balance of bunded rice fields is different from other areas. Moreover, the definition of drought for rainfed rice in these parts is different from the general definition. Even though the soils are at saturation, drought conditions prevail, as the beushening operation cannot be completed without standing water of 5-10 cm in the rice fields. The field water balance of bunded rice fields was computed and the changes in field hydrological characteristics under the changing rainfall conditions were examined. Using the water balance parameters, the water harvesting potentials in the village tanks under normal, excess and deficit rainfall conditions were calculated. Using this analysis, the areas where crop diversification is needed because of changing rainfall and field hydrological conditions during this century were identified. For poor farmers such changing rainfall conditions are detrimental for their livelihood and hence, large scale migrations during lean periods are common. Here, the socio-economic factors due to changing rainfall conditions in relation to soil are discussed.

CHANGING RAINFALL, RAINFED RICE, SOCIO-ECONOMIC FACTORS, WATER HARVESTING, DROUGHT

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Linking land use and climate changes from Holocene incision and sedimentation in Roman and present day reservoirs, Central Ebro Basin Spain

Crisanto A. Silva Aguilera

Focusing on catchment-scale erosion, temporal variability within the last centuries, valley infill, gully erosion, sediment accumulation and storage loss in reservoirs is studied. Roman and present-day reservoir within the Huerva and Aguasvivas River, South of Zaragoza were selected in base of previous erosion rates investigations and the presence of several reservoirs since Roman times until the half of the 20th century. A methodology

was designed based in dating with ^{14}C AMS, GPR sections combined with GIS to quickly and efficiently assess sediment yield in ancient reservoirs and try to relate temporal sediment yield variability to natural background and human impact during Roman times. The bottom of the Muel dam infill provided an age of 2020 ± 30 ^{14}C yr BP indicating that the dam was constructed during the 1 century BC corresponding with the period of Augustus. A second sample located 4.25 m over the first one, showed an age of 1880 ± 30 ^{14}C yr BP. Results show that sediment yield values calculated at the Muel and Almonacid de La Cuba Roman dams are lower (10 times) than those provided by present day reservoirs (Las Torcas y Moneva). Differences in sediment yield will be related to important change in climate or land use change. Ancient water reservoirs would provide interesting information about climate and land use changes in the selected catchments.

ROMAN RESERVOIRS, HOLOCENE INCISION, EROSION, LAND USE, EBRO

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Holocene environmental changes in central Inner Mongolia based on single-aliquot-quartz optical dating and multi-proxy study of dune sands

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The results of optical dating of quartz and multi-proxy study of sand dunes from the Hobq and Mu Us Deserts, central Inner Mongolia were used to infer past environmental changes during the Holocene. The results indicate that widespread eolian sand mobilization occurred in the studied region during the beginning of the early Holocene from 11,500 to 9,300 years ago. The climate became warm and humid during the period between ~9,000 and ~5,600 years ago (Holocene optimum), as evidenced by soil development, rich pollen assemblage, high organic carbon content and relatively finer particle size of the eolian deposits. Our reported warm/humid Mid-Holocene optimum is consistent with other studies from the monsoonal regions, but inconsistent with the recent reported mid-Holocene aridity between 8,000 and 4,300 years ago in the same region. The warm/humid mid-Holocene optimum terminated around 5,600 years ago, and the climate became arid again after this time. However, the environmental changes during the late Holocene were affected by both climate and human impacts, and thus the formation of the uppermost sand bed is not only the result of climatic drought of the late Holocene, but also related to poor land-use practices.

OSL DATING, HOLOCENE, DESERT, PALEOCLIMATE

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Paleoenvironment during periods of human activity at the upper reaches of Keriya River, Kunlun Mountains, China

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Keriya River, which originates from Kunlun Mountains and fades away into the Tarim Basin northward, lies in the interactive zone between the Tibetan Plateau and the desert, and typical temperate continental climate and plateau climate underlying the westerly as well. Here, we present a 490 cm deep eolian-deposit section with interlayers containing charcoals and middens next to a tumulus on a terrace of Keriya River. It provides an opportunity to probe environmental changes related to human activities over the last 5.0 kyr. Based on data of grain size, TOC, calcium carbonate, traits of distinct environment stages are identified. A phase of more moisture lasted for 400 yrs After 4.8 cal kyr BP. Then, a period of drier and windier condition is inferred from 3.2 cal kyr BP to 2.7 cal kyr BP. During the period an unattractive humid event is recognized at about 2.85 cal kyr BP, showing the instability of climatic systems. Series of climatic fluctuations shown by grain size from 500 cal yr BP to 100 cal yr BP coincides with the temperature conditions during the Little Ice Age in the Guliya ice core, Kunlun Mountains. Some neighboring relics and cultural layers shifts are discussed briefly.

KERIYA RIVER, ENVIRONMENTAL CHANGES, GRAIN SIZE

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Assessing human impact on eastern Australian coastal lakes: A paleo-perspective

John Tibby, Peter Leavitt, Carl Sayer, Henk Heijnis

On Australia's east coast there are numerous coastal lakes that have variable levels of connection to the ocean, ranging from permanently "open"; to permanently "closed". As a result of high population concentrations on the coastal margin, these lakes are potentially among the most threatened in Australia. In parallel with many situations around the globe, little is known about the long-term status and function of these systems. Our investigations (using diatoms, phytoplankton pigments, plant macrofossils and stable C and N isotopes) firstly seek to document the pre-impact history of these lakes and then assess the degree of post-settlement impact. A particular focus of the first objective will be to develop an understanding of the effect of natural changes in opening regime on coastal lake ecology. In terms of assessing European impact, current studies focus on two fresh-brackish lakes that have recently experienced cyanobacterial blooms. These lakes have

contrasting levels of catchment development. Myall Lake lies in a predominantly forested national park, while a substantial proportion of Lake Ainsworth's (small) catchment is urbanized. We will investigate any pre-European precedent for recent cyanobacterial blooms and document post-settlement water quality and ecological changes.

EUTROPHICATION, COASTAL LAKES, DIATOMS, PIGMENTS

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Phasing of deglacial warming in the low-middle latitude of China: Comparison with bipolar ice core

Shuyun Wang, Lu Houyuan

The process and mechanism of deglacial warming had long been the hotspot of paleoclimate study. Phytolith studies on the Huguangyan Maar Lake, DGKS9603 core of East Sea, Weinan loess section show their respective characteristics in this period. Comparative analyses of Guliya ice core, Dongge cave, Hulu cave, BYRD ice core and GRIP ice core isotopic records in different regions all over the world demonstrate that the deglacial warming were not synchronous. Guliya and Huguangyan regions affected by Indian monsoon and southwest monsoon became warm first. The abrupt warming of Greenland lagged middle-low latitude regions more than 1.5~2 ka. We suggest that with the strengthening of solar radiation, tropic Pacific regions warmed and resulted the change of NADW, tropic regions drove the deglacial warming. Till now, it is still hard to determine the process and mechanism of deglacial warming. Therefore, much work is required to clarify this problem.

LOW-MIDDLE LATITUDE, PHYTOLITH, LAST DEGLACIATION, PALEOCLIMATE CHANGE, GLOBAL CONTRAST

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Seasonal change in $^{13}\text{C}/^{12}\text{C}$ ratio of dissolved inorganic and particulate organic carbon in three lakes of Taiwan: Imprints of carbon source and anthropogenic CO_2 ?

Tien-Nan Yang, Kuo-Yen Wei, Chung-Ho Wang, Teh-Quei Lee, Yue-Gau Chen

Seasonal variation in carbon isotope ratio of total dissolved inorganic carbon (DIC) and particulate organic carbon (POC) in three lake surface waters of Taiwan were investigated for the period of 2003-2004. The three lakes are Shuang-Lian Pond (at an altitude of 470 m) and Mei-Hwa Lake (50 m) in the northern Taiwan, and Long-Luan Lake (15 m) in the southern Taiwan. Values of $\delta^{13}\text{C}$ in POC of the three lakes fluctuated through time, but their linear trends are parallel and are in a narrow range envelop. For the two northern lakes the $\delta^{13}\text{C}$ values of DIC decrease with altitudes, implying different fractionation effect of CO_2 source from air. All the three lakes show consistently depleted trends in ^{13}C of DIC and POC during 2003-2004, reflecting probably the increased concentrations of emitted CO_2 and CH_4 in atmosphere from human activities.

CO_2 , CARBON ISOTOPE, LAKE, SEASONAL CHANGE, TAIWAN

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A new look at the causes of former human settlements' abandonment in the Taklamakan Desert, southern Xinjiang, western China

Xiaoping Yang, Feng Zhang, Bingqi Zhu, Zinan Liu

The Taklamakan Desert, located in southern Xinjiang, is over 330,000 km² in area, the largest desert in China. Earlier geomorphological investigations and archeological excavations have unearthed quite a lot meritorious relics in the extensive sand seas of western China, indicating vital human activity and prosperous economy in the early part of modern human history. In an attempt to have a more comprehensive understanding of the interaction between man and the environment, we comparatively studied the reports of the excavations and paleoenvironmental examinations, and historical literature with a special reference to the agriculture and the timing of the settlements' abandonment. In order to reconstruct river nets and wetland distributions in historical times hydrological descriptions in historical books were transformed to modern topographical maps.

In addition to the human settlements, the length of the rivers and the extension of the wetlands are taken as environmental indicators in this study also. A primary scheme showing the Holocene evolutions of human activities and the rivers' hydrology in the Taklamakan Desert is finally established, and their causal linkage is discussed as well.

HUMAN ACTIVITY, DESERT, GLACIER,
PALEOHYDROLOGY, CHINA

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From the catchment to the Lake: Magnetic susceptibility of soils and lacustrine sediments in the Longgan Lake Basin, Lower Reaches of the Yangtze River, China

Zhen-ke Zhang, Xiang-dong Yang, Hai-tao Tian, Hai-yan Ding

Since the 1970s, environmental magnetism has found extensive applications in diverse research areas of geosciences. In the field of paleolimnology, environmental magnetism was an important proxy to reconstruct past environmental changes. Lake sediments mainly came from the lake catchment. Magnetic parameters provide useful information about the relationship between the catchment soils and the lake sediments. Here, the magnetic susceptibility of the soils and lacustrine sediments in the Longgan Lake Basin in the lower reaches of the Yangtze River is discussed. We studied one core from the middle part of the lake and soil samples from the basin. All samples were dried at low temperatures, less than 30°C; and ground into powder before magnetic analysis. Magnetic susceptibility and frequent susceptibility were measured on a Bartington MS2 susceptibility meter. The values of magnetic susceptibility of the soil in the Longgan Lake catchment are obviously different from each other. From the higher altitude area to the lower plain around the lake, the values of magnetic susceptibility decline. The magnetic susceptibility of the lake sediments has more similarity with the values of the lower farmland. There is an obvious change of the surface magnetic property from the hill to the lake. From the catchment to the lake, the changes of the magnetic susceptibility of the lake sediment and soils indicate the following possible facts: from the high land to the flood plain of the lake the magnetic minerals may be transformed because of sedimentary environmental changes, which resulted in the decrease of the magnetic susceptibility.

MAGNETIC SUSCEPTIBILITY, SOIL, LAKE SEDIMENT

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Paleoclimatic changes inferred from $\delta^{13}\text{C}$ record of peat profile on the north-bank of Yangtze in Nanjing area since the last stage of the late Pleistocene

Chaogui Zheng, Cheng Zhu, Hua-Zhong Gao, Hong-Yuan Sheng, Chun-Mei Ma

Based on analysis of the organic carbon isotope of the peat stratum in Linfengqiao profile at the north bank of the Yangtze River in Nanjing area since the last stage of the Late-Pleistocene, the $\delta^{13}\text{C}$ values of both the upper and lower peat stratum are lower than -23.79%, which indicates that their organic matter is from C3 plants. In addition, the $\delta^{13}\text{C}$ values of the upper peat stratum are higher than those of the lower. ^{14}C dating indicates the upper peat stratum is mainly formed in Holocene Megathermal and the lower peat stratum is mainly formed in the period of the Younger Dryas, which shows that the formation of peat is not absolutely controlled by climate changes. Combined with other research conclusions, it is confirmed that the Holocene Megathermal Maximum is between ca. 8.2 cal ka BP and 7.0 cal ka BP in this area. Before and after this period, the temperature was lower for a shorter time. During 12.8 to 12.1 cal ka BP, temperature fluctuates frequently in this area. The temperature is lower in the two periods of 12.8 to 12.7 cal ka BP and 12.6 to 12.2 cal ka BP, which could contrast with the events of the Older and Younger Dryas, respectively. The temperature during 12.7 to 12.6 cal ka BP is higher, which could contrast with the Allerød event. In the period of 12.2 to 12.1 cal ka BP, after the Younger Dryas event, the climate becomes warmer rapidly, so it could be regarded as the beginning of Holocene.

PEAT, $\delta^{13}\text{C}$, LATE-PLEISTOCENE, CLIMATIC CHANGE, NORTH-BANK OF THE YANGTZE RIVER IN NANJING AREA

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Session 3: Ocean-Continent-Cryosphere Interactions - Past and Present

As part of the attempt to converge towards a more holistic understanding of the Earth System, this session addresses interactions between its major components. Approaches include data analysis and computer modeling on different timescales, ranging from seasonal-scale modern-day observations to million-year-scale changes during the Neogene Greenhouse-Icehouse transition. Papers are presented that test or refine particular ideas of Earth component coupling and others that seek to put new paleoenvironmental observations into an Earth System context.

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Global biogeochemical cycles and greenhouse gas emissions in the ice core paleo-perspective*Hubertus Fischer, EPICA gas consortium*

CO₂ and CH₄ represent the most important greenhouse gases, second and third only to the natural water vapor content of the atmosphere. Accordingly, they play a major role in the radiative budget of the earth and, thus, are mainly responsible for an ongoing and future anthropogenic warming. However, they represented also a crucial ingredient for climate changes and the buildup of large ice sheets in climate history. In return, bubble enclosures in the ice sheets from both polar regions represent a unique direct archive of atmospheric composition in the past. As a matter of fact, most of what is known about the temporal evolution of the anthropogenic increase in greenhouse gases over the last 150 years is derived from ice cores. But Antarctic ice-core records also reach far back in time and only recently the EPICA (European Project for Ice Coring in Antarctica) Dome C ice core allowed for a reconstruction of climate changes and atmospheric composition over the last eight glacial cycles. Here, latest results on atmospheric paleorecords from ice cores are presented, extending the CO₂ and CH₄ record back in time to approx. 650,000 years before present, a time characterized by glacial cycles of significantly reduced amplitude in the EPICA Dome C ice core. In addition, recent developments in the interpretation of those records, in terms of glacial/interglacial changes in biogeochemical cycles, are presented using high-resolution CO₂ and CH₄ data from (bipolar) ice cores and other records, the carbon isotopic signature as well as simplified models.

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Reconstructing the last 2000 years of climate through ICARA (Ice-core Climate Archive Recovery Activity)

Paul A. Mayewski

Holocene-age abrupt climate change events, although less dramatic than their Glacial age counterparts are, nevertheless, revealed in a variety of globally-distributed paleoclimate proxies. These events are closely correlated with significant changes in both the course of human civilization and ecosystems. Further because Holocene-age abrupt climate change events occurred under geographic boundary conditions similar to those in existence today, these events and the Holocene paleoclimate record in general offer insights into the underpinning of modern climate. The most recent, and arguably the most prominent, Holocene-age abrupt climate change event is the Little Ice Age. Examination of a globally distributed array of well-dated, continuous, calibrated paleoclimate series covering the last 2000 years offers significant insight into the timing, magnitude, and variability that characterize the Little Ice Age. Paleoclimate records documenting changes in temperature, hydrology, and atmospheric circulation demonstrate complexity that is instructive with regard to understanding the causes and importance of this event relative to the advent and future of modern, anthropogenically impacted climate of the last few decades. Warming over the last few decades threatens to destroy some of the most robust paleoclimate archives—ice cores recovered from mid-to-low latitude sites. The combination of these mid-to-low latitude ice-core records and those collected from polar latitudes is needed in order to further the understanding of global-to-regional scale climate change. To undertake such a massive global collection and interpretation requires an international effort—ICARA (Ice-core Climate Archive Recovery Activity).

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Towards modeling the ice-core record of atmospheric trace gas and aerosol variations between glacial and interglacial times

Sandy P. Harrison

The large and systematic variations in atmospheric trace gases and aerosols between glacial and interglacial periods, documented by polar ice-core records including the new EPICA core, provide a challenge to our understanding of the natural regulation of the atmospheric oxidizing capacity and greenhouse gas content. The problem is complex, and requires insight into changing terrestrial and marine sources and sinks, the physical and biological processes which control emissions from the ocean and land surface, and the complex physical and chemical transformations that take place during atmospheric transport. Recent developments in the field of biogeochemical and atmospheric chemistry modeling, coupled with the existence of global syntheses of paleodata documenting changes in climatic and environmental conditions, are already helping to provide a better understanding of the role of various competing or complementary processes in the natural regulation of atmospheric composition. While much of the work so far has focused explicitly on the carbon, methane and dust cycles, algorithms for the climatic control of biogenic emissions of other key reactive species are being developed. A push towards coupling these components into the next-generation Earth System Models will be required before we are able to fully answer the challenge posed by the ice core record.

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Climatic events and tendencies in the North-West Pacific recorded by trees and glaciers during the last 400 years

Olga Solomina, R. D'Arrigo, G. Jacoby, G. Wiles, Ya Muraviev, T. Shiraiwa

A number of climatic proxies (tree rings, including ring width, light rings, missing rings chronologies, dates of moraines, melt features and $^{16}\text{O}/^{18}\text{O}$ variations in the ice cores) are employed to extend understanding of North Pacific climate variability over the past four centuries. New oak, spruce, larch and birch chronologies were developed for this purpose in Kamchatka peninsula, Kurile and Sakhalin Islands. Based on oak ring widths, summer temperatures since AD 1634 were reconstructed for Kunashir Island. The oak chronology is also used to reconstruct PDO variations during the last four centuries. Two composite larch chronologies for the Kamchatka peninsula are used for a qualitative estimation of summer temperature, and a reconstruction of June temperatures since AD 1632 was developed. The tree-ring based temperature reconstruction in Kamchatka is in good agreement with melt-feature percentage from Ushkovsky glacier. Decadal variations of summer temperature in Kamchatka and Alaska during the last 400 years were found to be similar in amplitude and timing. This similarity may help explain the synchrony of glacier advances in the two regions. The decadal variations of summer temperature at Kunashir are similar to those in Kamchatka and Alaska for the period 1750-1850, but after 1850 the similarity disappears. Light rings in the Kamchatka chronologies indicating cool early summers or short warm seasons coincide with missing rings or precede them by one year. Some light rings can be associated with well-known climatically worldwide effective volcanic eruptions with a lag of 1-2 years.

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The tropics and rapid climate change—records of changes in rainfall and atmospheric circulation from speleothems

Stephen J. Burns

Precipitation in the tropics is dominated by seasonal movement of the Intertropical Convergence Zone (ITCZ) over the oceans and associated development of the monsoons on land. On geologic timescales, the mean location and intensity of tropical rainfall can vary greatly. These changes are reflected in the oxygen isotope ratio of rainfall, which are recorded in the oxygen isotope ratio of speleothem calcite. Study of the timing and pattern of changes in precipitation can help identify causal mechanisms. During the last glacial period, speleothem records of precipitation from the northern hemisphere tropics show a remarkable correspondence to changes in temperature at high northern latitudes. The millennial-scale Dansgaard-Oeschger cycles of slowly decreasing and rapidly increasing temperature recorded in Greenland ice cores appear as slowly decreasing and rapidly increasing monsoon rainfall in stalagmites from Socotra Island in the Indian Ocean. Results from a speleothem from Brazil in the southern hemisphere, however, show very little variation in tropical climate associated with the D/O cycles. Instead, variation in precipitation and circulation follow the precessional cycle of solar insolation. Taken together, these records suggest that the northern limit of annual ITCZ migration was strongly influenced by ice cover and temperatures in the high northern latitudes, while the southern limit of ITCZ migration remained primarily under the influence of solar insolation. During the Holocene, rainfall and ITCZ migration in both the Northern and southern hemisphere tropics appear to respond in a nearly linear fashion to insolation. Speleothems from the both Oman and Brazil indicate a slow southward migration of the mean ITCZ location, which resulted in decreasing Indian Monsoon precipitation and increasing South American Monsoon precipitation. Superimposed on these trends, at least in the northern hemisphere, are rapid climate events associated with temporary decreases in NADW formation at 8.2 ky BP, and less prominently at 9.2 ky BP.

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From Milankovitch to rapid climate change—IMAGES Research

Ralph Schneider

IMAGES (International Marine Global Change Study) is a core program of Past Global Changes (PAGES) and is affiliated with SCOR. IMAGES was initiated about 10 years ago to respond to the challenge of understanding the mechanisms and consequences of climate change using ocean sediments as a the main archive. The overriding IMAGES goals are to quantify physical and chemical variability of the ocean on timescales of oceanic and cryospheric processes, e.g., from Milankovitch to Decadal timescales; to determine its sensitivity to identified internal and external forcing, and to determine its role in controlling atmospheric CO₂. In order to achieve these scientific objectives, IMAGES coordinates a global program to collect and study marine sediment records to address three fundamental questions: 1. How have changes in surface ocean properties controlled the evolution of global heat transfer through the surface and deep ocean circulation? 2. How have changes in ocean circulation, ocean chemistry, and biological activity interacted to generate the observed record of atmospheric pCO₂ over the past 400 kyr? 3. How closely has continental climate been linked to ocean surface and deep-water properties? This contribution will present key results of IMAGES studies addressing the above scientific objectives in all major ocean basins. Special emphasis will be given to inter-hemispheric climate linkages, as well as to role of the North Atlantic and North Pacific cold water spheres in deep-water formation, the tropical oceans warm water pools and heat transport to high latitudes.

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The thermohaline circulation in past, present and future climate

Gavin Schmidt

There is strong evidence that thermohaline circulation changes have influenced climate on decadal-to-millennial timescales in the past. However, direct measures of such variability are sparse, both in the paleo-record and in the modern oceans. Models of this circulation produce qualitatively similar results, but in projections of future climate, the variation among different models is very large. This is partly due to the difficulty in evaluating the models' response to various forcings. I will discuss the utility of using the last clear abrupt climate change in the Greenland ice core record (the 8.2 kyr event) as a test case for the models. Results from multi-proxy simulations of the event will be assessed to examine whether this can help reduce uncertainty in the future projections.

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Climate and the Ob River Runoff: What's happening?

Leonid Agafonov

It notes increase of annual precipitation over the northern Hemisphere during the last 50-70 years, especially for the cold seasons. Some authors note an increase of the average annual fresh water discharge from Eurasia rivers to the Arctic Ocean for the last 70 years. The Ob river is one of the great rivers of the northern Hemisphere and transports from south to north an amount of heat of more than 1010 MJ. Also the Ob plays a crucial role for climate of the Lower Ob region during the ice-free period. There are both cooling and warming effects of the Ob's streamflow to air temperature. We analyzed annual precipitation records from 61 weather stations over the Ob catchment basin southward from 60°N (2.72 mil. km²). These data was compared against daily water level records of the ice-free period from 5 gauge stations in the Lower Ob for the last century. Significant positive correlation between cold season precipitation and runoff of the Lower Ob river was revealed. At the some time there are difference in the long-term dynamics for the both parameters: positive trend for precipitation and negative one for the Ob runoff. And what is more, changes in hydrologic parameters (breaking- and freezing-up dates, etc.) are observed over the Lower Ob. What is the cause of these phenomena?

CLIMATE CHANGE, RUNOFF, WEST SIBERIA

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The sedimentary archive beneath Lake Pukaki, South Island, New Zealand, and its potential for providing a millennial to annual scale record of past climate change in the SW Pacific

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Lake Pukaki in central South Island contains a thick, fine-scale sedimentary archive which has the potential for being one of the best terrestrial mid-latitude records of past climate change in the southern hemisphere. Pukaki occupies a formerly glaciated trough at the head of the Waitaki River, and is located in New Zealand's most glaciated catchment, with modern glaciers presently covering >210 km². Dammed behind moraines of the Last Glacial Maximum (LGM), Lake Pukaki is an exemplary sediment trap containing a near-complete record of sediment delivery from the catchment and information on climate change since the Last Termination retreat of ice, ca. 17,600 cal yr ago. Recently acquired seismic data show up to 400 m thickness of finely, parallel-reflective sediments overlying acoustic basement (glacial till) in the southern central portion of Lake Pukaki. This reflection character suggests a relatively undisturbed

lacustrine sedimentary sequence. The sediment thickness and likely age span implies an average of 2 cm of sediment representing a single year, indicating a very high-resolution record. We intend to form an international research consortium to retrieve a sediment core from Lake Pukaki and document the annual-scale climate history that it contains. The data would provide a critical linkage between nearby ice cores from the Southern Alps and adjacent high-resolution marine records (e.g., ODP181-1119). A high-resolution post-LGM climate history from Lake Pukaki will greatly enhance our understanding of climate periodicity connected with abrupt climate events and ENSO signals but also their economic and environmental impacts in a catchment that New Zealand heavily depends on for its hydroelectricity generation.

LAST GLACIAL MAXIMUM, LAKE PUKAKI, POST-GLACIAL, PALEOCLIMATE, WAITAKI CATCHMENT

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Limnic response to DO-cycles: Exemplified from the sequence of Les Echets, France

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Dansgaard-Oeschger (DO) cycles and Heinrich events (HE) have been intensively studied in ice-cores and in marine sediment records, while studies demonstrating the impact of these events on land are still sparse. To fill this gap, a Swedish-French-American team recently obtained two long sediment sequences from the site Les Echets in central France (45°54'N; 4°56'E). This basin, which formed during the penultimate deglaciation, provides a continuous sedimentological record covering the last glacial period and has a strategic position with its proximity to the northern Hemisphere ice-sheets, the North Atlantic and the Mediterranean. Of the two sequences recovered in 2001, one was located in the central part (core 1) and one in the shallower part (core 3) of the basin. The focus of our multi-proxy study is on OIS 3 (60-30 ka BP), a period characterized by several HE and DO-cycles. A well-constrained chronology (AMS ¹⁴C, OSL) will make it possible to correlate the sequence with ocean and ice-core records, thereby identifying the extent and impact of HE and DO-cycles on the European continent and to determine if there are leads or lags between ocean, atmosphere and land. This will contribute to the understanding of mechanisms and causes behind these abrupt climatic events. Here, we present preliminary results, based on LOI, biogenic silica and diatom assemblages, which indicate dramatic

fluctuations in the lake's organic production and which can be interpreted as a strong response of the limnic environment to the millennial- and centennial-scale climatic variations during OIS 3.

DO-CYCLES, OIS 3, BIOGENIC SILICA, DIATOMS

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Problems of the orbital theory of paleoclimate: A new way for their solution

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The well-known discrepancies between Milankovitch theory and empirical data show that this theory has defects and needs in critical analyses of its basic assumptions. Unfortunately, nobody came to the second logical conclusion; almost all investigators tried to solve the problems within the framework of the Milankovitch version of the orbital theory. Such a passive position led to new inconsistencies. Carried out by the author (1998-2001) critical analyses revealed that the main drawbacks in the Milankovitch theory are the following. When calculated the quantitative insolation changes, connected with the variations of the every orbital element, Milankovitch did not take into account their qualitative differences. The next drawback is the consideration of the semiannual (summer) insolation at individual (65°N) latitude as orbital forcing for the Earth climatic system. Calculated in such a way insolation variations do not represent the whole changes of radiation really affecting the global climatic system during tens of thousand years. So, correct paleoclimatic models should take into account the following aspects: (a) specific character of the continuous in time (for each month of the year) and space (for the whole Earth) insolation variations, related to the variations in all three orbital elements, and (b) individual (but not linear or nonlinear) terrestrial climatic feedbacks transforming insolation signal of each orbital element into global climatic changes. Concretization of such individual feedbacks, especially for the precession and eccentricity variations is the most important challenge

now. This approach solves the problems of the orbital theory from the unified system of notions.

ORBITAL THEORY, MILANKOVITCH, INSOLATION, FEEDBACKS

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Scientific drilling of 3.6 My record at El'gygytyn Crater Lake, Northeast Siberia

Julie Brigham-Grette, Martin Melles, Pavel Minyuk, Christian Koeberl

Lake El'gygytyn, located in central Chukotka, NE Russia, is a 3.6 million year old impact crater lake with a diameter of 12 km and a water depth of 170 m. During recent years the sedimentary record of the lake has become a major focus of multi-disciplinary multi-national paleoclimatic research and is now a world-class target for deep drilling. A full-length sediment core would yield a complete record of Arctic climate evolution; back one million years prior to the first major glaciation of the northern hemisphere. The catchment of the crater was never glaciated during the entire Late Cenozoic. A 12.9 m long sediment core retrieved from the deepest part of the lake in 1998 recorded the past 250 ka, and confirmed the lack of glacial erosion. This core also underlined the sensitivity of this lacustrine environment to reflect high-resolution climatic change. A 16.7 m long sediment core taken in 2003 confirms the reproducibility of the record and dates to nearly 300 ka. The first single channel seismic survey in 2000 and multi-channel seismic surveys in 2003 suggest a depth-velocity model of brecciated bedrock overlain by a suevite layer, in turn overlain by two undisturbed, lacustrine sedimentary units up to 400 m in thickness. In January 2005, we requested funds from ICDP for a drilling campaign in El'gygytyn Lake in spring 2007. Our goal is to collect the most unprecedented record of climate change in the terrestrial arctic for comparison with lower latitude marine and terrestrial archives of hemispheric and global climate evolution.

ARCTIC, PALEOLIMNOLOGY, CRATER, RUSSIA, CLIMATE

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Contrasting ocean circulation and hydrography of the northeast Pacific Ocean: Holocene vs. last Glacial conditions

Jose Carriquiry, Alberto Sanchez, Alexander van Geen, Joseph Ortiz, Tom Marchitto, Yan Zheng, Walter Dean

The North East Pacific (NEP) Ocean has received very little attention in terms of its hydrography and regional circulation at glacial and interglacial timescales, compared with its western counterpart, and much less with the Atlantic. Using newly generated $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ data measured in benthic foraminifera from sediment cores collected off the southern Baja California Pacific margin, and combined with published data from the Pacific Ocean basin margins, in this study we emphasize in the main features of Pacific Ocean circulation contrasted at glacial and interglacial timescales. The $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ profiles at depth do not seem to show appreciable differences during the Holocene and last Glacial, except at depths less than 2,000 m. Both isotopic profiles show a tendency towards more positive values, corroborating that during the last Glacial period existed a clear bathyal thermocline/nutricline starting at ~2000 m depth, and confirming that this may be a global phenomenon. The $\delta^{13}\text{C}$ profile of the NE Pacific is 0.4‰ lower than the western Pacific, over the upper 1.5 km of depth. This suggests that during glacial conditions, the NEP maintains a water column with relatively higher biological productivity and larger oxygen consumption (with the concomitant decrease in ventilation) than its western counterpart. Alternatively, the possibly also exist that waters of equatorial origin predominate (volumetrically) in the region in proportion to the more ventilated waters originating from the North Pacific.

VENTILATION, PRODUCTIVITY, CIRCULATION, GLACIAL, BAJA CALIFORNIA

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Ancient record of atmospheric ^{13}C from phytolith occluded carbon

John Carter

A new method is used to generate a last glacial record of atmospheric ^{13}C . This ^{13}C record is derived from the analysis of carbon trapped within phytoliths (plant micro-fossils). Phytoliths are microscopic opaline particles formed in plant cells. They are produced in many plants as their cells fill with silica, forming a solid body. Fragments of the original cellular material are often trapped inside the silica body. Phytoliths are highly resistant to decomposition, thereby protecting the original cellular material from post-depositional contamination, and these phytoliths are released directly to the adjacent soil when a plant dies and decays. When plants assimilate atmospheric CO_2 they fractionate against ^{13}C , leaving an atmosphere enriched in ^{13}C . Therefore, any record of isotopic change in plant tissue can be used as a proxy for change in atmospheric ^{13}C and by extension records changes in global vegetation. A relationship was established between the carbon isotopic ratios of the leaf tissue and the phytolith occluded carbon for a number of modern indigenous grasses, trees and ferns. Phytoliths were extracted and occluded carbon analyzed from a 7.4 m loess core. Changes in phytolith assemblages were used to create a direct record of changes to the local vegetation cover and the occluded carbon isotope analysis to generate a record of atmospheric ^{13}C for about the last 120,000 years. These results show a close relationship between changes in terrestrial vegetation cover and the ^{13}C record from analyzed phytolith occluded carbon.

PHYTOLITHS, CARBON ISOTOPES, ATMOSPHERIC CO_2 , PALEOCLIMATE

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Orbital variations of East Asian monsoon-induced precipitation and productivity in the western Pacific

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The northward moving of humid air masses that are driven by the increases of summer solar insolation in low latitudes normally form stationary fronts (Mei-Yu front) on the East Asian continent. The Mei-Yu front that characterizes with high precipitation rate, especially in Yangtze River basins, leads to huge amount fresh water inputs and reduces the salinity of surface water in the East China Sea (ECS). Water mass balance models reveal that more fresh water inputs into ECS continental shelves induce more nutrient upwelling to the surface from the bottom water, which in turn enhance marine productivity in the ECS. This study

presents paleoceanographic proxies that are measured from core MD012404 taken from the Okinawa Trough for the purpose of monitoring long-term productivity and monsoon-related environmental changes in the ECS. The average values of TOC/N ratio are mostly lower than 8, implying that the organic matters preserved in the sediments are mainly derived from marine productivity. Opal variations of this core show a similar pattern with TOC and the high values of both biogenic components coincide with high summer insolation mainly driven by precession variations. The synchronous changes between summer insolation and TOC and opal contents suggest a possible linkage between the precipitation patterns on East Asia associated with summer monsoon and the marine productivity in the ECS. The short-term variations of productivity records of core MD012404 also show similar structure with stadial/interstadial air temperature variations in Greenland ice cores, implying a close linkage between the East Asian summer monsoon and northern hemisphere high latitude climate.

TOC, OPAL, PALEOPRODUCTIVITY, SUMMER MONSOON, PRECIPITATION

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Millennial-scale climate change and the chronology of events: New input from high-resolution CH₄ records

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Rapid climatic variability over the last glacial is recorded in Greenland and Antarctic ice cores through fast and usually large-amplitude variations of the methane atmospheric mixing ratio. We will present the status of the high-resolution CH₄ records obtained on the EPICA/Dome C (Antarctica) and North GRIP (Greenland) ice cores. These data have numerous applications, including: - characterizing the biogeochemically-mediated climate response associated with Dansgaard-Oeschger events, based on Greenland CH₄ records and associated permanent gas isotope measurements - determining the millennial-scale climate variability during previous glacial periods and Terminations, using Antarctic CH₄ as a proxy for North Atlantic climate shifts - testing the consistency of climatic parameterization used as model inputs for the densification model simulating the trapping of gases

in Antarctic ice; the confrontation of the EPICA/DC and Vostok gas chronologies using CH₄ as a stratigraphic marker provides a new tool for this evaluation.

METHANE, CHRONOLOGY, DANSGAARD-OESCHGER, EPICA, NORTH GRIP

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A numerical study of the South Atlantic Circulation at the Last Glacial Maximum

Gabriel Clauzet

In this study we examine the simulation results from the paleoclimate version of the National Center of Atmospheric Research coupled climate system model for the Last Glacial Maximum in order to understand changes relative to the Present Day related for the South Atlantic (SA) circulation. Results show that at subsurface levels there are two distinct patterns: i) intensification of the mass transport for the LGM in the southern SA (35°S to 25°S); ii) weakening of the mass transport in the northern SA (25°S to the equator). At intermediate layers, there is an intensification of the subtropical gyre and a northward shift of the South Equatorial Current (SEC) bifurcation for the LGM. This leads to the intensification of the southward mass transport by the Brazil Current (BC) and the associated BC recirculation cell in the southern basin for the LGM. This shift in the position of the SEC bifurcation leads to a weakening in the northward transport and also in the western recirculation of the central SEC in the northern basin. This northward shift of the SEC (upper limit of the subtropical gyre) is consistent with the northward shift observed on the subtropical convergence zone and suggests a displacement of the sub-tropical gyre 3-5 towards the equator. At deeper layers, a shallower and weaker North Atlantic Deep Water (NADW) circulation at the LGM contributes to the reduction of the southward transport in the northern part of the basin and permits a higher intrusion of the Antarctic Bottom Water. This intrusion plus the increase of the

Indian Water inflow is responsible for the northward transport intensification in the southern basin.

PALEOCLIMATE, LAST GLACIAL MAXIMUM, SOUTH ATLANTIC, OCEAN CIRCULATION, COUPLED CLIMATE MODEL

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Cloud feedback in an ensemble of ice age experiments

Michel Crucifix, PMIP2 participants

A series of experiments has been conducted with state-of-the-art models (HadCM3, FOAM, LMD5, ECHAM5, MIROC3.2). Here, we analyze the amplitude of the cloud feedback, with emphasis on tropical oceans. Results at the time of abstract submission are preliminary and only concern some models. It is seen that, locally, the net cloud forcing tends to be linearly related to the deviation of sea-surface temperature with respect to the mean. This is observed when analyzing interannual variability (present-day and ice-age), as well as when comparing the mean glacial state to the pre-industrial equilibrium. This observation leads us to amend the usual feedback theory to define a quantity referred to as the 'local gain' due to the cloud response, estimated here at around 2.

PMIP2, CLOUD, GENERAL CIRCULATION MODEL

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Linking up the Sun and Indian summer monsoon rain through ocean sediments

Moumita Das, Anil K. Gupta, David M. Anderson

The population study of planktic foraminifer *Globigerina bulloides* from the deep-sea sediments of the Arabian Sea is used to decipher the variations in monsoon intensity. The strength of the Indian summer monsoon and the North Atlantic climate change have been found to be closely related during the last glacial period as well as the present interglacial. There is good resemblance between the *G. bulloides* record of monsoon variability and the percentage of hematite stained grains from the North Atlantic throughout the Holocene. The production rates of cosmogenic nuclides (^{14}C and ^{10}Be), reflecting changes in solar activity, are closely tied to the Bond cycles in the Holocene. Recent studies document that the summer monsoon intensity has been positively related to changes in solar insolation not only at orbital scale but also centennial and decadal scales. Comparison of a recently published record of Holocene sunspot activity with our high-resolution record of the Indian

summer monsoon winds from rapidly accumulating and minimally bioturbated sediments of the northwest Arabian Sea reveals intervals of summer monsoon minima during the time of lower sunspot numbers (decreased solar activity). Our results suggest that small changes in solar irradiance can bring significant changes in the tropical monsoon at multidecadal timescales.

INDIAN MONSOON, SOLAR VARIABILITY, HOLOCENE

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Late Cenozoic climate and habitat change in northwestern China from the carbon isotopic record of herbivore tooth enamel

Tao Deng, Yang Wang

Cenozoic deposits of the Linxia Basin in northwestern China contain abundant and well-preserved mammalian fossils. The $\delta^{13}\text{C}$ values of tooth enamel from 116 individual teeth, representing 13 different herbivore forms and an age range from 25 Ma to 2.5 Ma, fall between -8.4 and -12.4‰, and indicate a diet dominated by C3 plants for all herbivores. The $\delta^{13}\text{C}$ differences among species indicate a mixed habitat in the basin that probably included woodland/grassland mosaics, C3 grasslands and forests throughout much of the Paleogene and Neogene. However, the Quaternary tooth enamel and soil $\delta^{13}\text{C}$ values indicate that C4 grasses have been an important component of local ecosystems in the area since at least the Middle Pleistocene. This is in striking contrast to what was observed in Pakistan, Nepal, Africa and Americas where C4 plants expanded rapidly at about 7-5 Ma as indicated by a positive $\delta^{13}\text{C}$ shift in mammalian tooth enamel and paleosols. The lack of evidence for C4 plants in the Linxia Basin prior to ~2.5 Ma suggests that East Asian summer monsoon was probably not strong enough to affect this part of China throughout much of the Neogene. This implies that the Himalayan and the Tibetan Plateau may not have reached the present-day elevation and extent to induce a strong monsoon circulation before ~2.5 Ma and regional climatic conditions played an important role in controlling the expansion of C4 plants.

CARBON ISOTOPE, TOOTH ENAMEL, NORTHWESTERN CHINA, CLIMATE CHANGE, LATE CENOZOIC

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Post-paleocene discordance revealed by palynologic analysis in the petroleum borehole Tiémié 1 (South-West Ivory Coast)

Zéli Bruno Digbehi

The study of the palynoflora of the interval 320-80 m of Tiémié 1 well permits the identification of three sub-stages of the Paleogene: the Upper Paleocene (320-220 m), the Middle Eocene (220-150 m) and the Upper Eocene (150-80 m). This palynoflora especially indicates plants of inshore vegetation (mangrove) dominated by palmaceae. Five palynological facies identified along the interval traduce a depositional environment oscillating between the marginal domain and the inner continental shelf. One especially notes a continental major influence during the Middle Eocene. This study especially reveals the lack of Lower Eocene, inducing a stratigraphical hiatus of the Middle Eocene over the Upper Paleocene. These new palynostratigraphical data lead to modify and to complete a stratigraphy earlier established from the only microfauna.

PALYNOFLORA, TERTIARY, MARINE SERIES, TIÉMIÉ 1, IVORY COAST

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Stepwise expansion of desert environment across northern China in the past 3.5 Ma and implications for monsoon evolution

Zhongli Ding, Shiling Yang, Jimin Sun, Edward Derbyshire

A systematic study of the last glacial cycle along three transects across the Chinese Loess Plateau shows that sand-sized particle content within loess decreases rapidly from north to south, and that markedly high sand particle contents in loess horizons occur only in the northern part of the Plateau. This suggests that variation in the sand-sized particle fraction within loess near the desert margin is closely linked to migration of the southern desert border in northern China where sand grains move mainly in saltation or modified saltation mode near the ground surface. As desert margin shift is essentially controlled by the amount of monsoon precipitation, the sand-sized particle content within loess is regarded as a new and readily applied proxy for variations in the strength of the East-Asian summer monsoon. A continuous record of sand content in loess along the loess-desert transitional zone shows that the Mu Us Desert migrated southward at 2.6, 1.2, 0.7 and 0.2 Ma, suggesting a stepwise weakening of the East-Asian summer monsoon during the past 3.5 Ma. This evolutionary pattern is significantly different from that previously inferred from loess magnetic susceptibility records, a widely used monsoon proxy. Our results further suggest that changes in global ice

volume may have been an essential factor in controlling Plio-Pleistocene monsoon evolution, and that the anticipated future melting of polar ice cover may lead to a northward migration of the monsoon rainfall belt in northern China.

EAST-ASIAN SUMMER MONSOON, LOESS, MU US DESERT, SAND CONTENT, PLIO-PLEISTOCENE

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Are deglacial chronologies across the southern hemisphere over the past 100 ka regionally synchronized?

David Fink

Correlations of millennial scale glacial climate transitions across Earth's hemispheres is presently the centre of much debate. Such studies are predicated on securing reliable and absolute chronologies of glacial cycles with inter-comparisons on the mode and volume of glaciation. Issues such as synchronicity or otherwise of the Younger Dryas cooling prevalent in the northern hemisphere, the determination of a 'global' nature for the Last Glacial Maximum, and linkages between glacial continental and off-shore ocean records, are key questions to understand the teleconnections and mechanisms of past global climate change. These issues are now being addressed from a southern hemisphere perspective by the wide spread application of cosmogenic exposure age dating using ^{10}Be and ^{26}Al produced in moraine boulder deposits and glaciated bedrock surfaces. Our exposure age data sets from numerous recessional moraine sequences and glacial terraces in Tasmania and New Zealand covering altitudes from 500 to 1500 m asl indicate (1) no evidence to support significant glacial readvance commensurate with the YD chronozone, (2) no proximal or cirque moraines appear with formation ages younger than 14-16 ka indicating all major ice sources had dissipated by the mid LGIT period, (3) a definitive, common age for the LGM remains elusive with age ranges between 20-26 ka, and (4) MIS 8-12 with a weak MIS-2 glacial record is preserved in Tasmania while in New Zealand MIS-4 is by far the largest glacial stadial during the last glacial cycle. These broad results show remarkable similarities to new ages emerging from southern Chile.

GLACIAL CHRONOLOGY, COSMOGENIC DATING, GLOBAL SYNCHRONICITY, SOUTHERN HEMISPHERE

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The hydrological cycle on a greenhouse Earth—different from today

Sascha Flögel

Numerical model simulations of the present day “icehouse” and Cretaceous “greenhouse” climates suggests both an enhanced hydrological cycle during the Cretaceous and very different partitioning between surface and subsurface runoff. In our present day simulations, global mean subsurface runoff (groundwater, ~24,874 km³/yr) is ~75% of total river discharge (~34,528 km³/yr) whereas ~25% of the total river discharge entering the sea today is surface runoff (~9,654 km³/yr) from snow melt and intense rainfall. Here, we present climate model data from a greenhouse analog showing a modified hydrological relationship, with subsurface runoff (~85%) strongly enhanced relative to surface runoff (~15%). In the model, this is due to both reduced snow accumulations and widespread slower rainfall, more evenly distributed throughout the year. As a result, total river discharge is dominated by water from subsurface runoff—importing the chemical characteristics of groundwater. These simulated changes in the hydrological cycle imply fundamental differences in weather during greenhouse versus icehouse climates, with enhanced chemical weathering in the former and increased mechanical weathering in the latter. During the Cretaceous, enhanced chemical weathering would have greatly increased nutrient input into epeiric and shelf seas with important implications for ocean productivity.

CRETACEOUS, GREENHOUSE, GROUNDWATER, RIVER DISCHARGE, WEATHERING

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Variations in tropical convection as an amplifier of global climate change at the millennial scale

Raja Ganeshram, Tara Ivanochko, Dick Kroon

New multi-proxy reconstructions of the intensity of the Arabian Sea Summer Monsoon from Somali and Indian margin sediment cores show strong millennial-scale variability over the past 90 kyr in coherence with temperature records from Greenland ice cores. These reconstructions of upwelling-induced biological productivity (bio-Ba, organic carbon), upper intermediate water oxygenation ($\delta^{15}\text{N}$) and dust inputs (elemental ratios) suggest lower monsoon intensity during the glacial and stadial periods, which is reflected as lower biological productivity, decreased denitrification and increased aridity in surrounding land areas. Gradual decline in monsoon intensity over the last 10 kyr in response to precessional forcing is also inferred from the Holocene records. We interpret that the decline in monsoon intensity during the cold periods are associated with a southern shift of the Intertropical

Convergence Zone, which when viewed in conjunction with previously reported tropical paleoclimatic records suggests that global scale millennial climatic variability is in part driven by modulations in the tropical hydrological cycle. We suggest rearrangements in the tropical convection system globally affected the concentration and location of atmospheric water vapor and modulated terrestrial and marine emissions of CH₄ and N₂O, providing a tropical mechanism of amplifying and perpetuating millennial-scale climatic changes. The global expression of millennial-scale climatic change and the persistence of this signal in Holocene records point to atmospheric teleconnections as the mechanism propagating rapid climate variations.

ARABIAN SEA, MONSOON, MILLENNIAL, HYDROLOGICAL CYCLE, UPWELLING

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Orbital and millennium scale climate and environment changes of the Okhotsk, Bering Seas and far northwestern Pacific during late Quaternary

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Several deep-sea sediment cores recovered from the Okhotsk, Bering seas and the far northwestern Pacific were studied using isotope-geochemical, lithological, micropaleontological and lithophysical methods. The sediment age model of these cores was reconstructed by $\delta^{18}\text{O}$ benthic foraminifera curves, AMS radiocarbon dating, tephrochronology, and the temporal pattern of sediment magnetic susceptibility variability. The surface and deepwater condition changes were studied by means of planktonic foraminifera $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ measurements, plus diatom, planktonic foraminifera and radiolarian species variability. Changes in the sea ice formation and in its spatial extent were reconstructed by counting the ice rafted debris and taking into account the content of sediment coarse fractions. Bottom water conditions of the discussed region were investigated through the benthic foraminifera $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values and the benthic foraminifera abundance and species changes. The multiproxy analyses of the marginal sea and NW Pacific sediments manifest the regional climate, environment and sedimentation regime variability modulated by orbital and suborbital forcing. For MIS 2, 3 and 4 the millennium scale climate and environment changes of the region under study looked like the Dansgaard-Oeschger events founded in the Greenland ice core

(GRIP 2). During MIS 3 the pronounced climate warming and environment changes in the region occurred likely coeval with Dansgaard-Oeschger interstadials 14, 12 and 8.

ENVIRONMENT, VARIABILITY, OKHOTSK SEA, BERING SEA, LATE QUATERNARY

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High latitude "icy Heinrich events" vs. tropical "dusty Heinrich-like events": Are they teleconnected?

Francis Grousset, Elsa Jullien, Frédérique Eynaud, Bruno Malaize

Previous studies have allowed the clear identification of so-called "Heinrich events" and to portray their distribution in the Northern Atlantic. In the well-known West-to-East 40°N-55°N area of high IRD deposition, similar sequences occur. The internal dynamics of the North American ice sheet would trigger these cyclic Laurentide-derived iceberg surges. However, synchronous "Heinrich-like dusty events" observed in Greenlandic ice-cores could suggest an external climatic forcing? On the other hand, it is clear that tropical zones could play also an important role in the northern climate variability and that interconnections exist between low and high latitudes. Would these tropical events lead (and trigger?) the Northern Atlantic glacial abrupt events? Or could the apparently discordant climatic responses to Heinrich events be explained by a reorganization of the global atmospheric transport of heat and moisture? In order to better understand these spatial heterogeneities, we have considered a series of records reported in the literature. We add a new IMAGES core from the Saharan margin (MD03-2705) studied on a high-resolution mode. Results will be displayed: AMS ^{14}C , X-Rays, XRF-geochemistry, magnetic susceptibility, O_2 isotopes, CaCO_3 contents, grain-size, foraminifer, SST. Other analyses are still in progress (biomarkers, coccoliths,

diatoms). Based on well-constrained age-models, we aim to demonstrate if the tropical "dusty Heinrich like events" are (or are not) synchronous with the northern "icy events" and if they are only a consequence of the northern "icy events".

HEINRICH EVENTS, ATLANTIC OCEAN, ARIDITY, MOISTURE, CONNECTIONS

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Quaternary planktonic foraminiferal fauna and variations of the warm pool in the western Equatorial Pacific

Jin Haiyan, Jian Zhimin

As the main source of global heat and vapor, the Western Pacific Warm Pool (WPWP) acts as an engine of the global climatic system, therefore, the variation of the WPWP during glacial cycles has become the primary issue in Quaternary paleoclimatological studies. The analytic and calculation results from a study of planktonic foraminifera in the upper 25 m of ODP 130 Site 807 reveal that both the SST and upper water structure of the WPWP had significantly changed since 1.5 Ma. The glacial-interglacial winter SST difference was about 5.0~7.5°C; the fluctuation range of the depth of thermocline (DOT) was beyond 100 m. All the evidence mentioned above proved the variability of the WPWP, testifying the SST changes in tropical oceans. The variation of the WPWP is stepwise in the Quaternary, with the mid-Pleistocene Revolution at ~0.9 Ma as the most significant transition boundary. Prior to this boundary, the fluctuation ranges of the SST and DOT were very small; after that, the temperature increased in steps and the DOT deepened gradually which indicates the thickening of the upper warm water. Furthermore, the percentage abundance of the cold and warm planktonic foraminifera and the DOT changed in an opposite way during glacial/interglacial cycles across 0.9 Ma. According to spectrum analyses, the paleoceanographical changes in the WPWP display the synchronous impact of the high-latitude ice-sheet forcing and the low-latitude tropical forcing.

WESTERN PACIFIC WARM POOL, PLANKTONIC FORAMINIFERA, SEA SURFACE WATER, DEPTH OF THERMOCLINE, QUATERNARY

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Terrestrial NPP simulations in China since the Last Glacial Maximum

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Based on AVIM (Atmosphere-Vegetation Interaction Model), the magnitude and spatial distribution of terrestrial net primary productivity (NPP) in China is simulated during three different geological eras, Last Glacial Maximum (LGM), Mid-Holocene (MH) and the present-day. The simulation shows that the glacial-interglacial variation of East Asian summer monsoon in China is the key factor affecting the NPP change. During the three eras, mean NPPs are 208 g/m²/yr, 409 g/m²/yr and 355 g/m²/yr, respectively. The total NPP are 2.05 Pg/yr, 3.89 Pg/yr and 3.33 Pg/yr, respectively. The terrestrial NPP in China during warm-humid climate is larger than that during cold-arid eras, and the correlation analysis between NPP and climate factors suggests that temperature is the primary factor affecting the terrestrial NPP during 21 ka BP (LGM), and precipitation for 6 ka BP (MH) and present-day.

LAST GLACIAL MAXIMUM, MID-HOLOCENE, NPP, EAST-ASIAN MONSOON, CLIMATE CHANGE

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Interglacial climate modes in the northern North Atlantic across the mid-Pleistocene

Jan Helmke, Henning Bauch, Helmut Erlenkeuser

Deep-sea sediment core MD992277 (69°N, 6°W, 2800 m water depth) from the northern North Atlantic (Nordic seas) was analyzed by sedimentological, micropaleontological and geochemical means in order to gain insight into the regional climatic conditions of the mid-Pleistocene interglaciations between ca. 0.8 to 0.35 million years, i.e., marine isotope stages (MIS) 19 to 11. Based on the isotopic and faunal evidence it can be proposed that interglacial conditions were never fully established within both MIS 19 and MIS 17. The early Brunhes MIS 15 reveals a first enhancement of interglacial characteristics within the Middle Pleistocene epoch. Here, we find an interval with Holocene-like oxygen isotope values that parallels a minimum of deposition of iceberg-rafted debris and a substantial increase in the ratio of subpolar/polar planktic foraminifers. These observations point to the development of pronounced interglacial conditions in the study region at that time with a notable advection of warm surface waters from the subpolar regions of the North Atlantic. MIS 11 is the second isotope stage to show fully developed interglacial conditions within the studied time interval. However, the comparison with MIS 15 indicates that the full interglacial interval of MIS 11 seems to have persisted much longer before the Pleistocene climate system swung back into its more usual stadial or glacial mode. Hence, our study

indicates a gradual intensification of interglacial climate characteristics at high northern latitudes during the Middle Pleistocene interval that most probably was related to the overall changes of the mid-Pleistocene climate revolution.

NORTHERN NORTH ATLANTIC, INTERGLACIAL CLIMATES, MID-PLEISTOCENE

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Modern diatom-based interpretations of Holocene paleoenvironmental changes in Osaka Basin, southwestern Japan

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Paleoenvironmental surveys using diatom analysis have been carried out with drilling core samples and modern surface deposits in Osaka Basin, southwest Japan to obtain records of Holocene environmental changes. For the purpose of this study, bottom surface sediments were taken from 40 stations in and around Osaka Bay to assess the relationship between diatom assemblages in sediments and present-day environmental conditions. Then, fossil diatom assemblages of core samples drilled at the lowland area near the river mouth of the Yodo River were investigated to reconstruct changes of paleo-Osaka Bay during Holocene. In surface sediments, fresh water diatoms are dominant at eastern part of Osaka Bay and are less abundant toward the offshore. This distribution suggests the outflow and diffusion from the Yodo River (the biggest river in Osaka Basin). The distribution data of diatom assemblages made it possible to select some environmental indicators; *Stephanodiscus pseudosuzukii* is a good tracer for the freshwater influence from the Yodo River, and *Thalassionema nitzschioides* was indicative of the influence from open sea. Diatom assemblages of drilling core samples at the Yodo site were analyzed to clarify environmental changes during the last 10,000 years. The data obtained from the analysis of surface sediments are used for the interpretation of depositional environment derived from the diatom analysis of core samples.

DIATOM, HOLOCENE, PALEOENVIRONMENTAL CHANGE, OSAKA BASIN, YODO RIVER

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Variations in atmospheric ^{14}C during the Younger Dryas recorded in Tasmanian Huon pine tree rings

Quan Hua, Mike Barbetti, Ugo Zoppi, David Fink, Edward Cook

We have recently examined atmospheric ^{14}C during the Younger Dryas (YD, ~12,800-11,600 cal BP) using a sub-fossil Huon pine log. This log (catalogue SRT-783), containing 414 rings, was found in alluvial sediment in western Tasmania, Australia (42°S, 145°E). A total of 42 samples, mostly decadal samples, were taken from SRT-783 for AMS ^{14}C analysis. The AMS ^{14}C dates were fitted in the early YD, by wiggle-matching to Cariaco (PL07-58PC) marine varve data, which until now have been the most high-resolution data covering the YD episode. At the fitted position, atmospheric $\Delta^{14}\text{C}$ from the new ^{14}C dates shows decades-to-centuries variations, which are not seen in the Cariaco data, perhaps implying that the latter data are slightly smoothed by ocean circulation and uptake of CO_2 by marine organisms. For its older part, the Huon pine SRT-783 sequence has an overlap of ~100 years with the 1382-year-long floating Bølling-Allerød Pine chronology in southern Europe. Meanwhile for its younger part, there is a small gap between the SRT-783 sequence and the absolute tree-ring chronology. With the availability of 3 more Tasmanian Huon pine logs, which may belong to the middle to late YD based on preliminary ^{14}C results, this gap may be closed by measurements now in progress. This would allow a comparison of the inter-hemispheric ^{14}C offset across much of the YD, and provide reliable information to determine the causal factors for variations in atmospheric ^{14}C during the YD episode: changes in oceanic circulation, variability in solar activity, or both.

RADIOCARBON, TREE RINGS, YOUNGER DRYAS, OCEANIC CIRCULATION, SOLAR ACTIVITY

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Phase relationship in high precipitation events in East Asia during the last 150 ky

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Past variation in East Asian monsoon have been well documented using the sediment records from the Japan Sea as well as the Loess sequences inland China. These sediment records show 1-10 ky scale precipitation variabilities inland China associated with the East Asian summer monsoon. However, precipitation events on the Japanese Islands (Far East Asia) have not been well constrained in time domain because most of studies were conducted on terrestrial records and the ages were not determined as precisely as those for marine sediments. In order to reconstruct the precise timing of precipitation events on the Japanese Islands, we analyzed the mass accumulation rate, grain size, and mineral composition of detrital fraction, and pollen assemblage for a long giant piston core (MD01-2421, 45.82 m length) recovered from 2,224 m water depths on the Pacific side of central Japan. Detrital mass accumulation rate and pollen high precipitation indices are higher during later halves of MIS 1, 5a 5c, and 5d. Agreement of these two kinds of signals strongly suggests that the high precipitation events on Japanese islands during the identical periods. Highest precipitation events on Japanese islands reconstructed from Pacific side core delays by ~10 ky those in China reconstructed from Japan Sea core. These differences in the timing of maximum precipitation could be attributed to the southward shift and stagnation of frontal zone in summer extreme, which could promote longer rainy season on Japanese islands and less rain in northern central China at the same time.

EAST-ASIAN MONSOON, PRECIPITATION, DETRITAL FLUX, POLLEN, SEDIMENT CORE

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Impacts of snow and glaciers over the Tibetan Plateau on Holocene climate change: Model study

Liya Jin, Fahu Chen, Andrey Ganopolski, Martin Claussen

An Earth System model of intermediate complexity, CLIMBER-2, has been used to investigate the sensitivity of simulated global climate to Tibetan Plateau cooling over the last 9000 years (9 kyr). The simulations show that in the mid-Holocene at about 6 kyr before present (BP) the imposed cooling over the Tibetan Plateau induces summer precipitation decreases strongly in North Africa and South Asia, and increases in Southeast Asia. The response of vegetation cover to Tibetan Plateau cooling

is not synchronous in South Asia and in North Africa, showing an earlier and, hence, a more rapid decrease in vegetation cover in North Africa from 9 to 6 kyr BP while it has almost no influence on that in south Asia until 5 kyr BP. The simulation results suggest that the snow and glacier environment over the Tibetan Plateau is an important factor for Holocene climate variability in North Africa, South Asia and Southeast Asia.

HOLOCENE CLIMATE CHANGE, TIBETAN PLATEAU COOLING, MODELING EXPERIMENT

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Last millennium glacier variations and four centuries of climate change in the Elbrus area, Caucasus, Russian Federation

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Tree-ring analysis and a new lichenometric approach based on a combination of extreme value and Bayesian theories were used to re-estimate moraine ages of Elbrus area. 55 surfaces ranging from 3 to 700 years old were used to construct a new growth curve valid for the central Caucasus. Six new control points for Rhizocarpon section Rhizocarpon agree with the data reported previously by Serebryanny et al. (1984) and Seinova & Zolotarev (2001). Minimum tree-ring dates were obtained for several moraines of Bolshoy Azau, Terskol and Schkhelda glaciers. The tree-ring dates of moraines of Terskol glacier (1800s, 1850s and 1880s) are in a good agreement with the lichenometric and historical data. The age of the oldest trees growing on an end moraine of Bolshoy Azau glacier (AD 1614) brings evidence that the older lateral moraine, which terminates at the lower elevation and was previously dated as 17th century is in fact older than 13th century, judging by the lichenometric age of the end moraine mentioned above. Temperature sensitive, well-replicated ring width pine chronology (1614-2004) was constructed using the trees growing on the floor of Bolshoy Azau valley in the vicinity of the glacier in order to estimate climatic changes in the area during the last four centuries. The project (#16356) was supported by the PICS (France) and RAS (Russia) cooperation program.

LAST MILLENNIUM, GLACIER VARIATIONS, LICHENOMETRY, DENDROCLIMATOLOGY, CAUCASUS

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Possible solar control of centennial-scale cycles in the Early Holocene climate of NW Europe

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Hawes Water is a small (8 ha) carbonate lake located in NW England. Sediment cores from the lake have been used to reconstruct variations in climate since the Last-glaciation. A 9 m core, composed of relatively pure, shell-rich, micrite (>96% CaCO₃) was recovered spanning the Early-Mid Holocene. Contiguous 1 cm isotopic ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) analyses were carried out and used to monitor the impact and response of the local lake-catchment system to climatic change. The $\delta^{18}\text{O}$ record reveals substantial climatic instability. There are two periods of marked climatic deterioration, dated to approx. 9.4 ka BP and 8.2 ka BP based on U-series chronology. Even the times of relatively stable climate show significant changes. Spectral analysis and filtering of the $\delta^{18}\text{O}$ data reveal persistent regular cyclicity with a period of around 500 years. Interestingly, the two episodes of most marked climatic deterioration, recorded elsewhere in Europe, have been correlated with periods of decline in the North Atlantic circulation, and they correspond to amplified peaks within the centennial-scale cycles. Cross spectra of $\delta^{18}\text{O}$ with $\Delta^{14}\text{C}$ (taken as an indicator solar activity) for 8000 to 11,300 calendar years before present show significant coherency and common spectral peaks at periods of around 550 years. These variables are also in phase - lower $\delta^{18}\text{O}$ or colder temperatures correspond to negative $\Delta^{14}\text{C}$ or less solar activity. This implies that the centennial-scale periodicity may in part be due to indirect climate-forcing via subtle changes in solar activity.

OXYGEN ISOTOPES, SOLAR FORCING, HOLOCENE, CYCLICITY, CARBONATE LAKES

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Mediterranean Sea freshwater budget evolution through glacial and interglacial times

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Micropaleontological and stable isotope records from foraminifera have been used to study the changes of sea-surface temperature and salinity of the Mediterranean Sea during the late Quaternary. Results show that the Mediterranean Sea Surface Salinity depends on that of the North Atlantic water crossing the Gibraltar Strait, on the residence time of salt within the basin and on the local freshwater budget. Under modern conditions, the evaporation exceeds the sum of precipitation and river discharge and the freshwater balance for Mediterranean Sea is negative. In the easternmost part of the Sea, surface salinity is higher than that of the incoming Atlantic water by about 3%. The Mediterranean freshwater budget was however completely different at the time of sapropel formation in the Eastern Mediterranean basin. During these intervals, the surface salinity of the Mediterranean Sea was either equivalent or slightly lower than at Gibraltar Strait. These salinity decrease events, not observed in the Atlantic Ocean, are best explained by an increase in the river runoff and precipitation over the Sea. The freshwater input was therefore able to equilibrate the water loss by evaporation and the Mediterranean Sea has ceased to be a concentration basin. During the Last Glacial Maximum, water exchange between the Mediterranean Sea and the North Atlantic Ocean was reduced because of the sea level lowering and the resulting decrease in the Gibraltar sill depth. This increased the residence time of salt in the Mediterranean basin. Thus, glacial surface salinities were higher than today in the eastern basin, without a significant change of the freshwater budget.

MEDITERRANEAN SEA, GLACIAL, INTERGLACIAL, SEA SURFACE SALINITY, FRESHWATER BUDGET

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Regional response of continental Asia to global climatic changes: MIS11 records from Lake Baikal

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Lake Baikal sedimentary records reveal important details about the environments and climatic changes of Asia over 8 Ma. The Lake Baikal MIS11 record (423-362 Ka) has the highest biogenic silica accumulation, reflecting the warmest regional climate and highest productivity of Lake, during the past 450 ka. According to Baikal's diatom record, warm interglacial conditions in Asia were uninterrupted during 32 Ka, making MIS11 the longest interglacial in Siberia. However, this period of extremely long and warm interglacial conditions ended abruptly with a dramatic cooling at 394-390 ka that followed the deep insolation minima. This abrupt cooling resulted in a short (2 ka long) episode of regional mountain glaciation that left signs in the sediment of the Lake in the form of blue clay that is typical for glacials. This short regional glaciation caused significant changes in terrestrial and lacustrine ecosystems of the Lake Basin. Watershed vegetation dramatically changed from dark coniferous forests to a very sparse flora of dry glacial-like conditions. Remarkable changes also took place with the lacustrine ecosystem in both diatom productivity and diversity. Such deep cooling are not recorded in marine and other regional terrestrial records and, probably, reflects amplified response of continental Asia to insolation forcing due to sensitivity of continental landmass to insolation regime that was predicted by energy balance modeling. The significant increase of the North Hemisphere's ice volume during this short glacial event recorded in Siberia is simulated by LLN climatic models forced by insolation and variations of the atmospheric CO₂ concentration.

LAKE BAIKAL, ISOTOPE STAGE 11, ABRUPT GLACIATION, DIATOMS AND POLLEN RECORDS, CONTINENTAL RESPONSE

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Millennial-scale paleoceanographic change in the Japan Basin, East/Japan Sea during the late Quaternary

Boo-Keun Khim, Ken Ikehara, Tomo Irino

A variety of approaches were applied to the two gravity core sediments (GH99-1239 and GH99-1246) obtained from the Japan Basin (East/Japan Sea) to understand the late Quaternary paleoceanographic changes documenting the millennial-scale variations. Chronology was established using the stratigraphic correlation with known tephra layers and well-dated thick dark laminated mud (DLM) layer. The preservation potential of DLM depends on the water depth at a first approximation; the core from deepwater depth exhibits more numbers of DLM due to the low sedimentation rate and sensitivity to degree of oxygenation. Geochemical properties confirm the formation condition of DLM, corresponding to MIS 2 and MIS 6 as well as presumable D-O cycles. The concurrent paleoproductivity level can be estimated using TOC, opal, and $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ of sediment organic matter, although the decoupling between TOC and opal remains unexplained. Core GH99-1239, located in the high-sedimentation rate site, exhibits the typical glacial-interglacial paleoceanographic change along with particularly the interesting Holocene variability. Core GH99-1246, located in the low-sedimentation rate site, preserves the obvious millennial-scale paleoceanographic changes, which are associated with activity of East Asian summer/winter monsoon. Sea-level induced paleoenvironmental changes related to the glacials and interglacials are unique and basin-wide in the East/Japan Sea, featuring the supplementary monsoon effect governed by millennial-scale variation, resulting in the formation of thin dark laminated mud layers.

MONSOON, MILLENNIAL, EAST SEA, JAPAN SEA, LATE QUATERNARY

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High-resolution climate simulation of the Last Glacial Maximum

Seong-Joong Kim, Crowley Thomas

The climate of the last glacial maximum (LGM) is simulated with a high-resolution atmospheric general circulation model of NCAR CCM3 at spectral truncations of T170, corresponding to a grid cell size of roughly 75 km. LGM simulations were forced with the reconstructed CLIMAP sea surface temperatures, sea ice distribution, ice sheet topography, reduced CO_2 ,

and orbital parameters. When we force the model with the LGM conditions, global-mean surface temperature is reduced by 6°C and in the tropical lands the surface temperature reduction varies from -8°C to -2°C and -5°C on average. The decrease of surface temperature leads to a weakening of the hydrological cycle and annual-mean precipitation decreases by about 10%. However, in some regions such as the western part of USA, around the Mediterranean Sea, northern and eastern Africa, and the Middle East appears to be wetter in the LGM and these results are in a broad agreement with the paleoclimate proxy records. The presence of the Laurentide ice sheet leads to the splitting of the westerly jet over North America. This is consistent with previous simulations although this study used a lower elevated ice sheet. Overall, the high-resolution model captures detailed climate features over lands and its simulations are in a broad agreement with the observational proxy evidence.

LGM, MODELING, TEMPERATURE, PRECIPITATION, WINDS

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Isolation basin stratigraphy and Holocene relative sea-level change at the head of Kandalaksha Bay (White Sea), NW Russia

Vasili Kolka, Vladimir Yevzerov, Jakob Moller, Geoffrey Corner

The marine-lacustrine transition (isolation contact) in sediment cores from ten raised coastal lake basins situated 3.2-104.0 m asl in the Lesozavod area, at the head of Kandalaksha Bay (White Sea), was identified based on lithological and diatom analysis, radiocarbon dated and used to construct a relative sea-level (RSL) curve for the Holocene. All the lakes show a conformable, regressive I-II-III (marine-transitional-freshwater) facies succession in the uppermost part of the cores indicating a postglacial history of continuous emergence. The RSL curve shows rapid emergence between 10140±80 ^{14}C yr BP (lake 104 m asl) and 9170±80 BP (lake 59.9 m asl), a relatively low rate of emergence between 9170±80 BP (lake 59.9 m asl) and ~5000 BP (lake 30 m asl), and a moderate rate of emergence after 5000 BP. The low rate of emergence around 6000 BP probably correlates with the regional Tapes transgression. The shoreline displacement curve is similar to curves from different areas of Fennoscandia covered by the Scandinavian Continental Ice Sheet and indicates a heavy glacial loading. Four lakes, situated between 23 and 51 m asl and one at 104 m asl contain postglacial lake sediment (facies IV; non-laminated clay) in the lowermost part of succession, overlain by marine sediment (facies III; silt, sand, shells and shell

fragments). Shelly facies in the marine unit in the Lesozavod area include the following taxa: *Balanus* sp., *Echinoidea*, *Brachiopoda*, *Bivalvia* (among them *Tridonta borealis*, *Elliptica elliptica*, *Nicania montagui*, *Mya* sp.), and *Gastropoda* (among them *Puncturella* sp., *Oenopoda* sp., *Buccinum* sp.).

RSL, WHITE SEA, HOLOCENE, TAPES

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Late Pleistocene interglacial marine sequences in White Sea depression

Olga Korsakova, Vasili Kolka

Two tills of Saalian and Weichselian glaciations, interbedded by marine deposits, were established in SE Kola Peninsula. The marine deposits are represented by stratigraphically unconformable three formations of different age. The lowest marine formation (Ponoj strata) was formed during Boreal transgression and is remarkable for abundant macro- and microfauna, the formation age ranges from 130 to 100 ka BP. The upper formation (Strel'na strata) is represented by shallow coastal sediments and is poor in organic remains. From the ESR-ages of subfossil mollusk shells and OSL-ages of sediments, two marine transgressions in strata are distinguished. The second marine formation corresponds to Early Weichselian. The Early Weichselian sea was developed in southern Kola Peninsula during 100-80 ka BP. Transgression was interrupted by regressions and marine erosions during the cold sub-stages. Geological position of the formation in studied sequences indicates that the marine regime in southern Kola Peninsula was not disturbed during the whole period, corresponding to oxygen isotope stage 5. The coastal line migrated transgressively-regressively in the range 50-100 m above the present sea level. The climate changed repeatedly to the severe conditions. At the end of the Early Weichselian and the beginning of the Middle Weichselian the cooling was much more pronounced, that is evident from the glacial and fluvioglacial sediments in sequences of the SE Kola Peninsula. Overlying is the third marine formation. Their interglacial character is evident from the geological data and fossil availability. From age determination (55-60 ka BP) it corresponds to Middle Weichselian (oxygen isotope stage 3).

MARINE DEPOSITS, BOREAL TRANSGRESSION, KOLA PENINSULA

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Proposing a mechanistic understanding of atmospheric CO₂ during the last 740,000 years - a contribution to the EPICA challenge

Peter Köhler, Hubertus Fischer

Paleoclimate records in ice cores revealed high variability in temperature, atmospheric dust content and carbon dioxide. The longest CO₂ record from the Antarctic ice core of the Vostok station went back in time as far as about 410 kyr BP. New measurements of dust and the isotopic temperature proxy deuterium of the EPICA Dome C (EDC) ice core covered the last 740 kyr, however, revealed glacial cycles of reduced temperature amplitude. These new archives offer the possibility to propose atmospheric CO₂ for the pre-Vostok time span as called for in the EPICA challenge. Here, we contribute to this challenge using a box model of the isotopic carbon cycle based on process understanding previously derived for Termination I. Our Box model of the Isotopic Carbon cYCLE, "BICYCLE", consists of ten ocean reservoirs, a seven compartment terrestrial biosphere and considers also fluxes of CaCO₃ between ocean and sediments. BICYCLE is forced by various ice core and marine sediment records to depict observed changes in temperature, sea level, lysocline dynamics, and eolian iron input into the Southern Ocean. Our results show that major features of the Vostok period are reproduced while prior to Vostok our model predicts significantly smaller amplitudes in CO₂ variations. The main contributions (in decreasing order) to the variations in pCO₂ were given by changes in Southern Ocean vertical mixing, exchange fluxes between ocean and sediment, sea surface temperature, North Atlantic deep water formation, iron fertilization, and Heinrich events.

CARBON CYCLE, MODELING, ICE CORES, CO₂

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Correlation of new palynoteratical indicators of geobotanical crises with paleoclimate of glacial-interglacial cycles and an environmental prognosis for the future *

Galina Levkovskaya

Palynoteratical complexes of sediments (past, present) are the new indicators of some geobotanical crises. The characteristics of some palynoteratical complexes were worked out on the basis of

palynoteral statistics collected since 1967 for: 1. natural "clean" subfossil sediments from different modern geobotanical-climatic forest and tundra subzones of West Siberia; 2. Pleistocene sediments of many regions (Transcarpathia: Korolevo bore pit 26 with five interglacials; East Baltic: late glacial sediments; Russian plain: some Kostenki sections with Italian-Flegrian volcanic ash; Uzbekistan: sediments that are synchronous with Flegrian eruption; Altai: Denisova cave with layers of stages 5-3; Caucasus: some cave deposits); 3. subfossil sediments from 30-km Chernobyl zone. Poster presents part of these materials as diagrams (pollen and new palynoteral), SEM-micrographs and correlation tables. It shows some regional types of palynoteral "responses" (appearance of some types of palynoteral complexes or their disappearance) of the plants generative spheres on: 1. moisture/temperature changes during climatic phases (cryohydrophilous, cryoxerophilous, thermoxerophilous, optimum, thermohydrophilous) within the Pleistocene glacial-interglacial or stadial-interstadial cycles; 2. CO₂ balance change during Flegrian eruptions between 40-33 kyr BP; 3. modern thermohydrophilous phase conditions (on space natural zonal climatic changes). Two types of long-term environmental prognoses are discussed: natural and anthropogenic (variant for CO₂ balance change).

GLACIAL-INTERGLACIAL CLIMATIC CYCLES, STADIAL-INTERSTADIAL CLIMATIC CYCLES, GEOBOTANICAL CATASTROPHES, PALYNOTERATICAL COMPLEXES

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Quaternary sedimentation of the western part of Xorkol Basin in the Altun Tage and record of the uplift of the Qinghai-xizang Plateau

Jian-xing Li, Yong-he Wang, Le-ping Yue, Pei-xi Xiao, Nan-yi Sun

Based on three years' regional survey, together with the sedimentary record, plantation surfaces, terraces, alluvial fans and other morphostructures; the assemble of morphostructures and the relation between all these and structure, we believe that the Altun Tage has uplifted more than 5000 m by 8 periodical uplifts. The process can be divided into 3 different stages: the Altun Tage shows drastic vertical movement in the early-middle Pleistocene epoch but there were two different quiet periods and two plantation surfaces at different altitudes were formed; the tectonic movement was weak and the Xorkol basin was filled in the late Pleistocene. The neotectonic movement was intensified and earthquakes occurred frequently in the Holocene epoch. The sedimentary record of the Xorkol basin and the mountain around the basin

record the process of uplift of the Altun Tage and are important evidence in reconstructing the uplift history in the Northeast of Qinghai-xizang Plateau.

ALTUN TAGE, XORKOL, QINGHAI-XIZANG PLATEAU, UPLIFT

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Paleomonsoon variability in southeastern China since the Last Glacial reflected by speleothem records

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The $\delta^{18}\text{O}$ record of Fengyu Cave (110°10'E, 25°12'N) stalagmites shows remarkable similarities with the $\delta^{18}\text{O}$ records of Hulu and Dongge Caves, revealing synchronous the summer monsoon intensity in southeastern China during 4-25 ka. Compiling these $\delta^{18}\text{O}$ records, we find that the summer monsoon was the weakest during 15-17 ka. Low summer insolation and Heinrich 1 event may not be the only driving forces for this summer monsoon minimum. Our hypothesis is that the maximum advance of polar ice sheet in Euro-Asian continents and mountain ice cap in Tibetan Plateau occurred during this period, which caused maximum southward displacement of monsoon trough. According to the $\delta^{18}\text{O}$ records, the summer monsoon intensity rapidly increased from 15 to 14.3 ka, and then slowly increased until at the end of the Bølling-Allerød (B-A) around 13 ka. In eastern China, timing of Termination I probably was at ~14.6 ka. Unlike Hulu and Dongge Cave records which show much heavier $\delta^{18}\text{O}$ values during the Younger Dryas (YD) than these during the late B-A and early-to-mid Holocene, the $\delta^{18}\text{O}$ values of Fengyu Cave do not vary significantly between 4-14 ka except a sharp decrease during 10-11 ka. This discrepancy may imply that the retreat of summer monsoon trough during the YD did not strongly affect climates around Fengyu Cave where is further south of Dongge-Hulu latitudes. The strongest summer monsoon appeared around 10.5 ka when the summer insolation reached maximum at 35°N. Since then, the summer monsoon gradually decreased toward the late Holocene.

SPELEOTHEM, OXYGEN ISOTOPE, PALEOMONSOON, SOUTHERN CHINA, FENGYU CAVE

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Late Quaternary paleoceanographic changes from the Banda Sea based on fossil diatoms

Chung-Ching Liao, Wei-Lung Wang

The West Pacific Warm Pool (WPWP) plays a significant role in climatic and oceanic changes on regional and global scales. The Banda Sea is included in the WPWP and its climate changes can help us understand global climate fluctuations. The sediment core MD012380 (5°45.64'S, 126°54.25'E) retrieved from a water depth of 3232 m in the Banda Sea was used to establish the changes in diatom abundance and the relative abundance of *Chaetoceros* spp. during the past 824,000 years. The variations of the absolute diatom abundance (ADA) ranging from 1.3 to 51.6*10⁶ valves/g dry sediment and the relative abundance of *Chaetoceros* spp. ranging from 9.5-50.2% may reflect the fluctuation of upwelling conditions. Values are high in glacial and low in interglacial sections and hence provide evidence of stronger upwelling conditions during the glacial period. ADA cannot indicate the productivity in the Banda Sea due to the effect of dilution. The result of a principal component analysis showed PC1 scores similar to the relative abundance of *Chaetoceros* spp., providing evidence that PC1 reflects upwelling intensity. A Td index can indicate the past temperature in the Banda Sea and it was first performed successfully in the southern hemisphere equatorial region

BANDA SEA, FOSSIL DIATOM, PALEOENVIRONMENT, UPWELLING

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Weathering, erosion, and East Asian monsoon evolution in South China and Indo-China during late Quaternary: Clay minerals in the South China Sea

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Here, we report high-resolution studies of clay mineral assemblages at ODP sites 1145 and 1146 in the northern South China Sea and cores MD01-2393 and MD97-2150 in the southern South China Sea combined with surface sediments along the Pearl, Red, and Mekong Rivers. Hydrodynamic and mineralogical studies on the two northern shelf sites indicate that illite and chlorite sources include Taiwan and the Yangtze River, while smectites originates predominantly from Luzon and Indonesia and kaolinite is primarily derived from the Pearl River. A similar mineralogical study combined with Rb, Sr, and Nd isotopes on the two southern shelf cores determines the Mekong River as the major source: illite and chlorite derived mainly from the eastern Tibetan Plateau; kaolinite derived mainly from active erosion of inherited clays from reworked sediments in the middle part of the Mekong Basin; smectites originated mainly through chemical weathering in the middle to lower reaches of the Mekong River. Smectites/(illite+chlorite) and smectites/kaolinite ratios for all sites are used as indices of chemical weathering rates and, in turn, the East Asian summer monsoon intensity, which is itself related to the summer solar radiation calculated for the northern hemisphere. Higher ratios indicate strengthened summer-monsoon winds and weakened winter-monsoon winds during interglacials. In contrast, lower ratios indicate a strongly intensified winter monsoon and weakened summer monsoon during glacials. The chemical weathering/erosional history suggests monsoon-controlled weathering and erosion over South China and Indo-China during late Quaternary.

CLAY MINERALS, EROSION, EAST ASIAN MONSOON, LATE QUATERNARY, SOUTH CHINA SEA

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Hydrochemical and isotope characteristics of spring water and travertine in the Baishuitai area (SW China) and their meaning for paleoenvironmental reconstruction

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A method of combining hydrochemical data logging and in situ titrating with measurement of stable carbon and oxygen isotopes was used to reveal the hydrochemical and isotopic characteristics in the Baishuitai travertine scenic area of SW China. It was found that the travertine-forming springs have a very high concentration of calcium and bicarbonate, and accordingly very high CO₂ partial pressures, which are not likely to be produced by biological activity in soil alone. Further analysis of the stable carbon isotopes of the springs shows that the high pressure of CO₂ is mainly related to an endogenic CO₂ source. That means the Baishuitai travertine is endogenic in origin. This is contrast to the commonly accepted saying that the travertine deposition in this study simply is a product of warm and humid conditions in a karst ecological environment. Rapid CO₂ degassing from the water is triggered by the much higher partial pressures in water than that of the surrounding air. Consequently, as the waters flow downstream of the spring the pH increases, the waters become supersaturated with respect to calcite, and travertine is deposited. The preferential release of ¹²CO₂ to the atmosphere results in a progressive increase of travertine δ¹³C downstream. This is concluded with a preliminary discussion of variation in travertine-forming water temperatures, according to differences in stable oxygen isotopic compositions of the travertine formed in different epochs at Baishuitai. It was found that the change in water temperature is as high as 13°C, i.e., from 23°C at about 2500 years BP, to 10°C at present. This may mainly reflect that the effect of geothermal source on water temperature is decreasing. The problems involved in paleoenvironmental reconstruction with endogene travertine are also discussed. They are the impacts of "dead carbon" (in both limestone and CO₂ gas) in radiocarbon dating and the enrichment in ¹³C of travertine by endogenic CO₂ and degassing of CO₂ from water, which has to be considered in paleovegetation reconstruction when using δ ¹³C data of the endogene carbonate deposits.

STABLE CARBON AND OXYGEN ISOTOPES,
ENDOGENIC CO₂ SOURCES, TRAVERTINE,
PALEOENVIRONMENT RECONSTRUCTION, SW CHINA

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Coccolith evidence for the Quaternary nutricline variations in the southern South China Sea

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Nutricline variations of the last 1560 kyr in the southern South China Sea was reconstructed using the relative abundance of the coccolithophore *Florisphaera profunda* in the ODP Site 1143. We find nutricline depth changed on two different timescales. One was long-term variation with large magnitude, and another was glacial-interglacial variation with high frequency. On the long-term scale, nutricline experienced four significant changes, which occurred at 900, 480, 260, and 50 kyr respectively. According to these changes, five stages could be divided for the last 1560 kyr. From 1560 to 900 kyr, the depth of nutricline increased gradually. Around about 900 kyr, nutricline abruptly became shallow and after then they remained stable until 480 kyr. The nutricline was very shallower during the time interval between 480 to 250 kyr. At 250 kyr, it became deep again and increased gradually until 50 kyr. After 50 kyr, the depth of nutricline decreased gradually up to present. On the glacial- interglacial scale, the variations in nutricline show two different patterns before and after 900 kyr. Before 900 kyr, nutricline was deep in the glacial periods and was shallow in the interglacial periods. But after 900 kyr, nutricline was deep in the interglacial periods and was shallow in the glacial periods. Spectral analysis of the relative abundance of *F. profunda* shows a similar trend. In addition to the eccentricity (113, 76 kyr), obliquity (55, 39 kyr), and precession (24, 19 kyr), we also find a 431 kyr cycle. The former three periods reflect glacial-interglacial variations in nutricline, and the period of 431 kyr reflects long-term variations in nutricline. We suggested that the variations in nutricline in the southern South China Sea were caused by the global and regional climate changes. Glacial-interglacial variations in nutricline are mainly controlled by the East Asian monsoon. And the long-term variations might be related to the global climatic events, such as the mid-Pleistocene Revolution and the mid-Brunhes event.

COCCOLITHOPHORES, FLORISPHAERA PROFUNDA,
NUTRICLINE, QUATERNARY, SOUTHERN SOUTH CHINA
SEA

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Sedimentary evidence of Pleistocene and Holocene changes in bottom-water oxygenation in the subtropical Mexican Pacific

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Biogenic and non-biogenic sedimentation in the Gulf of Tehuantepec is modulated by upwelling resulting from northerly winds passing through the Isthmus of Tehuantepec and the amount of dissolved oxygen in bottom waters. We present micropaleontological, and sedimentological evidence of a core collected in the upwelling-influenced region of the Gulf of Tehuantepec. MD02-2523 Core was collected as part of the IMAGES MONA cruise at 15°25.74'N and 94°14.33'W, 220 m water depth. ^{14}C data indicate an age of 44,490 yr BP at 960 cm. Below this level chronostratigraphy is not clear, therefore we only present the upper 10 m of the sedimentary sequence. Previous work with planktonic foraminifera in the area indicated the absence of upwelling during the last glacial maximum. Planktonic foraminifera in core MD 2523 support the presence of upwelling during the Holocene and deglaciation, and its absence during most of the Pleistocene. This pattern is corroborated by the sedimentary structure and fabrics, which during non-upwelling, stratified water-column conditions, appear homogeneous and bioturbated, while during times of upwelling appear more laminated and banded. Upwelling episodes are characterized by increased productivity in surface waters, which strengthen oxygen depletion in bottom waters, preventing bioturbation in sediments. Therefore, both biogenic and non-biogenic sediments indicate changes in the strength of the oxygen minimum zone during Holocene and Pleistocene.

PALEOCEANOGRAPHY, QUATERNARY, SUBTROPICAL PACIFIC, OMZ

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Stable carbon and oxygen isotopes in pedogenic carbonates from recent soils, Belarus and eastern Poland: Implications for paleoclimatic reconstructions

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The $^{18}\text{O}/^{16}\text{O}$ and $^{13}\text{C}/^{12}\text{C}$ ratios were measured in rhizoconcretions from surface soils (120 samples from 26 sites). The isotopic compositions exhibit high (yet regular) variation along vertical profiles of 50-120 cm thick carbonate accumulation horizons. Maximum $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values are noted roughly in the middle parts of the profiles. These values appear to be 3-5‰ higher than those detected in the underlying and overlying sections. Rhizoconcretions from soils developed on the upper slopes show 0.5-5.0‰ higher $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values than those from the soils at foothills. The values averaged for individual sampling sites correlate significantly with geographical coordinates of sites and with some climatic parameters. In particular, the $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values decrease eastward. According to the suggested linear regression model they are -6.5 and -7.8 at 21°E, and -10.1 and -9.8‰ at 32°E respectively. The isotopic values change parallel to changes in mean January air temperatures (T_{JAN}). The $\delta^{18}\text{O}$ values are -9.2‰ at T_{JAN} of -8.0°C, and are -7.1‰ at T_{JAN} of -5.0°C (the gradient is $\sim 0.7\text{‰}/1^\circ\text{C}$). The $\delta^{13}\text{C}$ values are -9.5‰ at T_{JAN} of -8.0°C, and are -8.1‰ at T_{JAN} of -5.0°C. In general, the oxygen isotope ratios in the rhizoconcretions formed below the depth of 150-200 cm (especially in clayey soils at the bases of river valley slopes) are close to equilibrium with mean $\delta^{18}\text{O}$ in modern atmospheric precipitation. The potential of using the $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values of authigenic carbonates from buried soils as proxies for estimating past climatic shifts in temperate climate regions is assessed.

OXYGEN ISOTOPES, CARBON ISOTOPES, SOIL CARBONATES, CLIMATIC CONTROL, BELARUS

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The response of foraminifera and coccolithophorid assemblages to sea-surface productivity induced by a transient climate change: Panama Basin during the last deglaciation

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The response of planktonic and benthonic foraminifera and coccolithophorids to transient climate change are explored in cores ODP677B (1.2°N; 83.74°W, 3,461 m) and TR163-38 (1.34°S; 81.58°W, 2,200 m), for the

last ~40 ka. Results suggest that the deglaciation interval was a time of increased productivity and a major reorganization of planktonic trophic webs. The succession between the planktonic foraminifera species *Globorotalia inflata*, *Globigerina bulloides*, and *Neogloboquadrina pachyderma* denote four periods of oceanographic change: (1) advection (24 to 20 ka), (2) strong upwelling (20 to 15 ka), (3) weak upwelling (14 to 8 ka) and (4) oligotrophy (8 ka to present). Strong upwelling for the deglaciation interval is supported by the low *Florisphaera profunda*/other coccolithophorids ratio and the high abundance of *Gephyrocapsa oceanica*. Benthonic foraminifera assemblage changes are different in both cores and suggest significant regional variations in surface productivity and/or oxygen content at the seafloor, and a decoupling between surface productivity and export production to the seafloor. The terrigenous input of the Colombian Pacific rivers is suggested as a possible mechanism. Finally, the *Globorotalia menardii*/*Neogloboquadrina dutertrei* ratio, is used to reconstruct the past influence of the Costa Rica Dome-Panama Bight and cold tongue upwelling systems. A northern influence is suggested for the late Holocene (after 5 ka), and the last glacial (before 20 ka), whereas a southern influence is suggested for the 20 to 5 ka interval. There is a correspondence between our reconstructed northern and southern influences and previously proposed positions of the Intertropical Convergence Zone (ITCZ) after the Last Glacial Maximum (LGM).

PALEOCEANOGRAPHY, PANAMA BASIN,
EASTERN EQUATORIAL PACIFIC, FORAMINIFERA,
COCCOLITHOPHORIDS

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A 70-ka stable isotope and organic carbon record from a deep-sea sediment core in the Bay of Bengal

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We have reconstructed sea surface temperature and salinity changes in the Bay of Bengal for the last 70 ka using $^{18}\text{O}/^{16}\text{O}$ and Mg/Ca ratios in planktonic foraminifera from a deep-sea sediment core SK-157-14. This gravity core (5°11.56'N; 90°5.97'E; water depth 3,306 m; core-length 3.4 m) provides a continuous record of the surface water characteristics for the last 3-70 ka. $^{13}\text{C}/^{12}\text{C}$ and C_{org} have been used to infer productivity changes at this location. The time framework of this core was developed using ten radiocarbon dates of the bulk

sediment samples and oxygen isotope stratigraphy. The $\delta^{18}\text{O}$ record of *Globigerinoides ruber* exhibits high glacial-interglacial amplitude ($\Delta\delta^{18}\text{O} \sim 2.2\text{‰}$), which is in agreement with other published records from this region. The $\delta^{18}\text{O}$ contrast between the Last Glacial Maximum (LGM) and Holocene, after correcting for global ice volume effect, is relatively high ($\sim 1.0\text{‰}$). This residual $\delta^{18}\text{O}$ could arise either because of $\sim 4\text{--}5^\circ\text{C}$ decrease in temperature or due to $\sim 3\text{‰}$ increase in salinity, or a combination of both. Mg/Ca ratios determined in *G. ruber* and *G. sacculifer* of this core and previously published records from the North Indian Ocean suggest a decrease in sea surface temperature (SST) by $\sim 2\text{--}2.5^\circ\text{C}$ during LGM. This means that 0.4-0.5‰ change in $\delta^{18}\text{O}$ can be attributed to temperature decrease and the remaining 0.5-0.6‰ is due to an increase in salinity by $\sim 2\text{‰}$. Hence the surface waters of this site were characterized by both, i.e., a decrease in temperature by $\sim 2\text{--}2.5^\circ\text{C}$ and an increase in salinity by $\sim 2\text{‰}$ during the LGM. Large fluctuations are observed in $\delta^{13}\text{C}$ (0.6 to 1.6‰) and C_{org} (0.2 to 2.7%) records, suggesting significant changes in productivity in the studied location. LGM sediments are characterized by high $\delta^{13}\text{C}$ and C_{org} carbon contents, indicating a significant increase in productivity during this period.

STABLE ISOTOPES, FORAMINIFERA, Mg/Ca RATIO,
ORGANIC CARBON, SST

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Mediterranean humid periods and sapropel formation during the last four climatic cycles

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We have analyzed the benthic foraminiferal fauna at high-resolution along the core MD84-641 (33°02' N; 33°38' E) recovered in the Eastern Mediterranean Sea and covering the last four climatic cycles. For each sapropel, the succession of benthic foraminifera assemblages displays that the decrease in the oxygen content of the eastern Mediterranean deep water was gradual. This contrasts with the abrupt decrease of the Sea Surface Salinity (SSS) associated with sapropel formation. It is now well established that the organic matter preservation on the bottom of the eastern Mediterranean Sea and sapropel formation were linked to the slowing in the deep water circulation of the Mediterranean Sea. This can only be possible when the Mediterranean Sea received an enhanced freshwater supply that was able to equilibrate the water loss by evaporation transforming the Mediterranean Sea into

a non concentration basin. However, hydrological conditions responsible for organic matter preservation events, seems to be different from one sapropel to another. This is indicated by differences in the duration and the installation rhythm of anoxic conditions. Benthic foraminifera did not disappeared completely during sapropels S10, S9, and S4 suggesting that anoxia was never reached during these episodes. On the other hand, anoxia occurred for short duration during cold sapropels S8 and S6. This suggests that climatic conditions conducing to the wet epochs, associated with sapropels, were not identical for all the eastern Mediterranean sapropels.

MEDITERRANEAN SEA, CLIMATIC CYCLE, SAPROPEL, BENTHIC FORAMINIFERA

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Seasonality of biogenic fluxes and production of planktonic foraminifera: Response to oceanographic variability in the northwestern Pacific

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Upper ocean environments such as seawater temperature, salinity, thermal structure in the water column, light intensity and food supply affect the production of lithogenic and biogenic particulate matter. To understand the processes controlling the formation of the sediment record, seasonal variations of biogenic particle and planktonic foraminiferal fluxes were studied through the observation of sediment trap in the Northwestern Pacific. Seasonally high total mass and planktonic foraminiferal fluxes were recorded at Subarctic stations during the period of intense stratification of surface water accompanied by high fluxes of organic matter and biogenic opal. Much lower fluxes of planktonic foraminifera, organic matter and biogenic opal marked subtropical water. In the Kuroshio Extension, production of biogenic particles, planktonic foraminiferal flux and the species composition showed strong seasonality in accordance with variations in the local hydrography, which is influenced by the shift of the meandering Kuroshio Current and by the interaction between the subarctic water mass and Kuroshio Extension waters. In addition,

the simultaneous increase in total foraminiferal flux with an increase in sea surface temperature (SST) as well as a strengthening in the stratification of the water column in the Pacific region.

BIOGENIC FLUXES, PLANKTONIC FORAMINIFERA, SEDIMENT TRAP, OCEANOGRAPHIC VARIABILITY, NORTHWESTERN PACIFIC

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Holocene climatic events in the Arctic Siberia recorded by pollen from Laptev Sea sediments

Olga Naidina, Henning Bauch

The pollen spectra from Laptev Sea sediments show that climate has been subject to changes in the past. Some of these changes have occurred over relatively short time intervals. The pollen records from near-coastal marine sediments can give reliable information of climate-related vegetational changes on surrounding land. During the last years and in the frame of the interdisciplinary research program "Laptev Sea System" several high-resolution (~100 yr/cm) pollen-rich sea cores have been collected in the Laptev Sea covering the last 11.3 calendar years (cal ka). Absolute pollen analysis with morphological investigation of pollen indicators using scanning electron microscopy was carried out on sediment samples collected at 10-cm intervals. Based on birch pollen values pollen diagrams can be divided into several cooling and warming events. The main component of pollen grains belong to shrub birch. Given the close relationship between oscillations in birch shrub/tree-line and mean summer temperature in Arctic Siberia, it should therefore provide a valuable proxy summer temperature indicator. Marine pollen records indicate that the warmest conditions occurred between 9.3 and 8.0 cal ka. Comparison with terrestrial (vegetation and pollen) records from the Laptev Sea surroundings show, that arboreal pollen grains content started to increase in abundance in marine sediments after 9.3 cal ka without time-lag at the same time that on land. It is concluded that paleoclimatic reconstructions associated with marine pollen records produce well-grounded evidence on the evolution of Holocene climatic conditions in Arctic East Asia.

HOLOCENE, CLIMATE, ARCTIC, SIBERIA, POLLEN

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Holocene paleoceanographic changes and glacial history of the Van Mijenfjorden, Svalbard

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An 18-m-long sediment core (MD99-2305) was retrieved during the IMAGES-1999 cruise with "R/V Marion Dufresne" from the outer basin of Van Mijenfjorden (77°46.87'N and 15°17.81'E), western Svalbard at about 110 m water depth. Here, we analyzed ca. 16 m sediment sequences spanning the last 12 calendar ka BP, except for the lower 2 m thick over-consolidated diamicton sediment. Based on detailed multi-proxies, including organic-geochemical parameters (TOC, C/N ratio, Rock-Eval pyrolysis, Opal, $\delta^{15}\text{N}$ and $\delta^{13}\text{C}_{\text{org}}$ values) together with lithofacies, magnetic susceptibility, benthic and planktonic foraminiferal occurrence, stable oxygen and carbon isotopes on benthic foraminifer *C. reniforme*, the core MD99-2305 well recorded the Holocene paleoenvironmental changes of the Van Mijenfjorden in western Svalbard. In general, the low HI and OI values throughout the sediment sequences fall close to the origin within a van Krevelen-type diagram and therefore, seem to reflect a predominance of terrigenous organic matter. This might be also supported by relatively higher C/N values of ≥ 10 throughout the sequences. In contrast, the $\delta^{13}\text{C}_{\text{org}}$ values ranging from -24 to -22‰ suggest that the organic matters supplied to the Van Mijenfjorden glaciomarine sediments seem to be a mixture of marine and terrigenous origin. In particular, the variations in $\delta^{13}\text{C}_{\text{org}}$ values through times have been strongly related to fluctuations in tidewater glacier behavior as well as productivity in the surface waters within the fjorden during the last 12 cal ka BP.

PALEOCEANOGRAPHY, HOLOCENE, VAN MIJENFJORDEN, SVALBARD, GLACIAL HISTORY

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Late Quaternary environmental changes and formational process of the Mekong River Delta, Vietnam

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The Mekong River Delta (MRD), one of the largest deltas in Southeast Asia, is located at the mouth of

the Mekong River, Southern Vietnam. The formational process of the MRD is composed of three phases: erosional phase, transgressive incised-valley filling and aggradation phases, and delta progradation phase. Estimation of the Last Glacial Maximum (LGM) sea level is about -120 m in Southeast Asia. The drop in sea level led to the lowering of base level of the Mekong River, downcutting of the river, and the formation of an incised valley system reaches over -70 m around the present distributary channels. After the LGM, sea-level has risen rapidly and reached to -60 m at about 13,258 cal BP. at the MRD. The accommodation space was probably created preferentially in incised valleys, which were effectively filled. The sedimentary succession of the incised-valley filling is 40 to 45 m thick consisting of estuarine sand and sandy silt facies indicates aggradation system and dated 15-7 ky BP. Terrace-like uplands of Late Pleistocene sediments are located on interfluvies. Sea-level rise was probably exceeded by the net rate of sedimentation and the formation of open bay mud facies, 10 to 13 m thick, indicates a maximum transgression at ca. 6.0-5.5 cal ky BP. During the sea-level highstand and the subsequent period of slightly falling in the last 6-5 ky, delta has been prograding. The progradational delta has evolved from a tide-dominated delta to the present mixed tide- and wave- dominated delta during the last 3 ky. These changes are well recognized by the depositional process and geo-morphological characteristics.

MEKONG RIVER DELTA, SEA LEVEL, SEDIMENTARY ENVIRONMENT, FORMATIONAL PROCESS, VIETNAM

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Are Sr, Nd isotopic compositions of terrigenous sediments in the Bay of Bengal related to monsoonal regimes and Northern Atlantic climate change?

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Erosional products from Himalaya-Tibet and Burman ranges deposited in the Bay of Bengal and Andaman Sea can provide a history of weathering and erosion in these regions, which is related to the paleoclimatic conditions. Here, we present strontium and neodymium isotopic compositions and grain size record for the last ~35,000 years of a deep sea sediment core (SK-157-14) on Ninetyeast Ridge (5°11.56'N; 90°5.97'E; core-length 3.4 m). The chronology of the core is developed using nine radiocarbon dates on the bulk sediments and oxygen isotope stratigraphy. Sr and Nd isotopic compositions of the detrital fraction (<150 μm) show low $^{87}\text{Sr}/^{86}\text{Sr}$ (avg. 0.715) and relatively high ϵNd (avg. -13), different from those of the distal and western Fan sediments, indicating a different source. It appears

that sediments at this site on Ninetyeast Ridge have been derived mainly from Irrawaddy river sediments (erosional products of Indo-Burman ranges consisting of cretaceous and oligocene sedimentary shales hosting volcanic dykes, ophiolites and the flysch derived from the eroded material of the inner volcanic arc of Burma), with a very minor contribution from the Ganges-Brahmaputra and Peninsular Indian Rivers. $^{87}\text{Sr}/^{86}\text{Sr}$ and ϵNd show considerable fluctuations at intervals of $\sim 5\text{-}7$ ka (interval of Heinrich events). Pulses of low $^{87}\text{Sr}/^{86}\text{Sr}$ and higher radiogenic Nd coincide with high silt content. These times may be related to the intensification of the northeast monsoon in response to northern Atlantic climate change. It appears that the source of sediments studied here and their transport pathways are greatly influenced by the winter (NE) monsoon at 5-7 kyr interval. During the northeast monsoon, the surface circulation in the Bay of Bengal is cyclonic, and increased sediment plumes from Irrawaddy River would have moved westward and been deposited at this location.

Sr, Nd ISOTOPES, MONSOON, WEATHERING, TERRIGENOUS SEDIMENTS, HIMALAYA-TIBET

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New modeling of the Vostok ice flow line and implication for the glaciological chronology of the Vostok ice core

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We have used new spaceborne (elevation) and airborne (ice thickness) data to constrain a 2-D1/2 model of snow accumulation and ice flow along the Ridge B-Vostok station ice flow line (East Antarctica). We show that new evaluations of the ice flow line geometry (from the surface elevation), ice thickness (from low-frequency radar data), and basal melting and sliding significantly change the chronology of the Vostok ice core. This new Vostok dating model reconciles orbital and glaciological timescales and is in better agreement with the Dome Fuji and Dome C glaciological timescales. At the same time, the new model shows significantly older ages than the previous GT4 timescale for the last glacial part, being thus in better agreement with the GRIP and GISP2 chronologies. Moreover, we study the influence of various parameters on the chronology of an ice core not situated on a dome, like the Vostok ice core.

ICE CORE, CHRONOLOGY, INVERSE METHOD, VOSTOK, INSOLATION

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Japan Sea paleoceanography during the late Pleistocene-Holocene

Vladimir Pushkar, Marina Cherepanova

Diatom data allow us to establish ten Latest Pleistocene-Holocene paleogeographic events. The formation of the sediments had been forced by directions and configurations of the paleocurrents, paleoclimatic changes and sea level fluctuations. The frequency of pelagic diatoms entrained into, and transported offshore by Primorsk Cold current as well as eastern branch of Tsushima Warm currents may represent fluctuations in surface current and northwest trade wind strength in the Japan Sea during interglacial summer monsoon periods. The change ratio sublittoral diatoms versus neritic marked the decrease activity of Tsushima, maybe Primorsk paleocurrents for the long winter seasons coastal ice cover, and strong influence of the Siberian winds to the configurations of the currents. These data have been used to explain glacial intensification of the winter monsoon and increased seasonality of sea surface temperature in the Japan Sea. The diverse of the diatom paleoassemblages from marine to freshwater compositions suggest high sea level variability probably from -130 m below to +3 m asl. So strong decrease in magnitude of a sea-level position causes change of the material and energy flux linkage between land and Japan Sea.

DIATOMS, PALEOPRODUCTIVITY, PALEOGEOGRAPHY, LATE PLEISTOCENE, JAPAN SEA

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Self-organizing maps in review: Recent applications in polar (paleo)climatology

David Reusch, Richard Alley

The global climate system and natural archives of its history are linear only by approximation. Available observational and instrumental records are inadequate for full characterization of natural variability; proxy histories from, e.g., ice cores and tree rings are thus necessary to more fully understand climate change, past and future. Linear tools have proven highly valuable in

understanding paleoclimatic records such as these, and others, but are inherently limited to linear relationships. Motivated by these and other reasons, we have assembled a suite of nonlinear, highly adaptive tools based on artificial neural networks and applied these tools to several problems in (paleo)climatology. Self-organizing maps enable unsupervised classification of large, multivariate datasets, e.g., time series of the atmospheric circulation or sea-ice extent, into a fixed number of distinct generalized states or modes, organized spatially as a two-dimensional grid, that are representative of the input data. When applied to atmospheric data, the analysis yields a nonlinear classification of the continuum of atmospheric conditions. In contrast to principal component analysis, SOMs do not force orthogonality or require subjective rotations to produce interpretable patterns. Results to date have been encouraging and include: improved reconstructions of past climates from ice-core and automatic weather station measurements; new perspectives on sea-ice variability; and a new look at Holocene variability in ice-core chemistry datasets. Further data are needed but we are optimistic that these neural-net techniques will prove a useful complement to the traditional linear approaches, capturing more of the rich nonlinearity of the earth system.

NEURAL NETWORKS, PALEOCLIMATOLOGY,
ANTARCTICA, SEA ICE, ICE CORES

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The position of the Intertropical Convergence Zone and paleoproductivity changes at the western Caribbean and their link with North Atlantic climate changes for the last 60 Ka

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The otherwise monotonic climate transition from the Last Glacial to the present Interglacial shows some abrupt and large-amplitude shifts whose global effects have affected climate conditions in Tropical America for brief periods. Because the Intertropical Convergence Zone (ITCZ) is the main teleconnection mechanism between the tropics and extra-tropics, we reconstruct oceanic productivity variations as a proxy of the mean annual position of the ITCZ in the Caribbean Sea. For this purpose, we analyzed benthonic and planktonic foraminifera faunas (>150 μm size fraction) from 70 sediment samples from ODP Core 999A (12°45'N: 78°44'W, Colombia Basin) for the last 60 ka. We calculated benthonic and planktonic foraminiferal accumulation rates (BFAR and PFAR), whose patterns are quasi-synchronous, with peaks in the early and mid isotope stage 3 (MIS-3) and the middle Holocene (~6 kyr BP), thus suggesting the coupling between sea-surface conditions and benthonic foraminifera. The

lowest TAFB and TAFP values occur during MIS-3 and 2 transition and during the whole MIS-2. Dominant planktonic foraminifera belongs to the tropical province that is more abundant during low-productivity periods. High productivity periods in MIS-3 are characterized by incursions of the transitional-subpolar province. These patterns of abundance suggest that in the early and mid-MIS-3, the stratification of the upper-water column was disrupted, possibly due to the intensification of the Guajira upwelling system. The comparison of our foraminifera data for the Colombia Basin with estimated (published) salinity, temperature and NADW formation from the North Atlantic suggests a strong link between oceanic productivity and ITCZ migrations and forcing from the North Atlantic.

LATE PLEISTOCENE, FORAMINIFERA, CARIBBEAN SEA,
PALEOPRODUCTIVITY, ITCZ

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Diagnostics and paleogeographic significance of giant current ripple marks

Alexey Rudoy

In the 1940s, some new geomorphologic forms were discovered in North America (J. Pardee) and in the 1980s in Eurasia (V. Butvilovsky, A. Rudoy), they were called "giant current ripples". Their development was associated with the processes which had occurred within the outflow channels during cataclysmic glacial superfloods—floodstreams (diluvial floods) resulted from the outthrows of great Late Pleistocene ice-dammed lakes. Giant current ripple marks are active channel relief forms which developed on the near-talweg areas of the pre-core parts of main valleys of cataclysmic outflows out of the outburst water bodies, the latter being of the ice-dammed origin, as a rule. These marks are morphologic and genetic macroanalogs of small sand ripples in the contemporary streams and rivers, but they are by two-three orders bigger in dimensions and are formed with boulders and pebbles with minor participation of smaller fractions. At the boundary of the 20th-21st centuries the publication activity of the opponent of the diluvial origin of giant current ripples became very active. Here, we present diagnostics of the giant current ripples according to their morphology and structure on the basis of the well-studied locations of the relief in different regions of the world.

LATE PLEISTOCENE, ICE-DAMMED LAKES,
SUPERFLOODS

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Glacial-interglacial surface $\delta^{18}\text{O}$ seawater variations from the equatorial Indian Ocean during the Late Quaternary period

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Precise knowledge of various climatic parameters over the geologic past is an essential input for developing and testing climate prediction models. Availability of such information from the tropical and equatorial oceans has become important in order to understand the role of tropical/equatorial world oceans in regulating global climate. In the present study based on coupled Mg/Ca and stable oxygen isotopic analysis of planktic foraminiferal species *Globigerinoides ruber* in a core collected from the equatorial Indian Ocean, we reconstruct the millennial scale $\delta^{18}\text{O}$ seawater variations over the late Quaternary period. During the last two glacial-interglacial transitions, the $\delta^{18}\text{O}$ seawater shows a variation of $\sim 1.5\text{‰}$. Sea surface temperature variations precede ($\sim 1\text{-}2$ kyr) the change in $\delta^{18}\text{O}$ seawater. Comparison of equatorial Indian Ocean $\delta^{18}\text{O}$ seawater variations with that of Pacific Ocean shows that the magnitude of glacial-interglacial variations in $\delta^{18}\text{O}$ seawater is similar to that of eastern equatorial Pacific Ocean $\delta^{18}\text{O}$ seawater variations.

$\delta^{18}\text{O}$ SEAWATER, EQUATORIAL INDIAN OCEAN, LATE QUATERNARY, Mg/Ca

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Millennial cyclicity in Canadian sockeye salmon (*Oncorhynchus nerka*) production: A window into large-scale environmental forcing mechanisms

Daniel T. Selbie, Bruce P. Finney, John P. Smol

Pacific salmon (*Oncorhynchus* spp.) are largely in decline throughout North America. Several conspicuous anthropogenic stressors have been linked to their decline (hydropower, harvest pressure, habitat destruction and hatchery influences). Recently, however, the influences of cyclical climate phenomena (e.g., Pacific Decadal Oscillation) have been shown to be substantial in altering salmon production over the period for which records exist. Lower frequency modes of climatic influence, however, have been suggested from a recent $\sim 2,200$ yr paleolimnological reconstruction of sockeye salmon in Karluk Lake,

Alaska, USA. We present analyses of recorded salmon escapement relationships to the Pacific Decadal Oscillation and a $\sim 6,000$ yr paleolimnological record of salmon production in Tahltan Lake, northern British Columbia, Canada. Cyclical, millennial-scale salmon production is evident since a period of substantial climatic reorganization in the region $\sim 4,000$ yr BP. Connections to climatic and solar drivers are discussed.

PACIFIC SALMON, PRODUCTION, BRITISH COLUMBIA, CANADA, MILLENNIAL CYCLICITY, PALEOLIMNOLOGY

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Changes in south-border permafrost conditions as a result of Ocean-Continent Interaction affecting South Siberia and North Mongolia

Vlad Sheinkman

The permafrost zone in South Siberia and North Mongolia spans the Altay-Sayan Mountain country and further south comes gradually to naught within the Mongolian steppe. Seemingly high temperature cryolithozone must prevail at this area. However high temperature freezing ($0 - -1^\circ\text{C}$) characterizes only the western part of the country (Altay); its eastern part (Big Sayan) is characterized by mid temperature freezing ($-1 - -2^\circ\text{C}$) whereas in the middle of the Big Sayan range freezing reaches -4°C . The reason is the effect of local factors at the background of ocean-continent interaction specificity. South of the region the Indian Ocean influence is blocked at present by Hindu Kush and Himalayas whereas the western winds hinder the Pacific effect but make for warming Altay by the Atlantic and West Arctic. Along with the increase in climatic continentality and respectively in degree of freezing from the West to the East the winter cold air mass flows down from the highest massif in the Big Sayan and makes for deep freezing the intermountain depressions south of it. At that only the Darhad depression is frozen to -4°C ; the neighboring Hovsogol depression is filled by a great lake body that damps the cold impact and hinders deep freezing. As a result the Darhad turns out the most south area (of about 51°N) where present-day small repeated ice wedges exist. During the Pleistocene Cooling cryolithozone advanced to the south but it kept the same main features. Though the West Arctic was frozen, Altay had been still warmed by the Atlantic and it is a reason that there is no evidence of deep freezing in the Pleistocene sediments here. Ice sheets at the North-West of Eurasia and glaciers in the high mountains made for a more increase in climatic continentality of the region and the

area with the repeated ice wedges had been advanced to the South Mongolia and Gobi Desert where at present pseudo-morphs after small ice wedges have been revealed. However all of them are of the MIS 2, i.e., of the strongest Late Pleistocene cryochrone. In the layers formed during the previous cryochrones there is evidence of high- and mid-temperature cryolithozone but there is no evidence of deep freezing.

PERMAFROST, CLIMATE CHANGE, HIGH MOUNTAINS, SIBERIA, MONGOLIA

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The discovery and significance of Cenozoic moraine in Beibei district, Chongqing, China

Licheng Shen, Shiyou Xie, Duoxing He, Tingyong Li, Gang Zheng

The Cenozoic moraine and the Glacier historical remains have been discovered in Beibei district, Chongqing through field investigation. We do research on it by the macroscopic sedimentary characteristic, the geochemistry characteristic of the rock and mineral, the granularity characteristic and the facies characteristic of quartz. The age of the model sedimentary moraine is determined by the ESR dating. The moraine and the gravel are probably the outcome of the Pliocene-Pleistocene glacier activity by the above researches and its physiognomy and location. And it is the results of multi-convey ways and multi-convey processes by the water and the ice and the density flow, and so on, together. They are mixed sediments, which are transported and deposited through the bottom and interior action of the glacier. Its sedimentary environment is the front of the glacier. There is a glacier activity at the Pliocene-Pleistocene era in the area or Huaying mountain. It can reflect the geological significance of the evolvement of Jialing River and Yangtse River, as well.

GLACIER HISTORICAL REMAINS, GLACIER ACTION, ESR DATING, BEIBEI DISTRICT OF CHONGQING

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Quaternary environmental changes of the Okhotsk Sea and its implication for global climatic changes, from mineral evidence of Core MD012414

Sheng-Rong Song, Ya-Jiun Liu

The Okhotsk Sea is characterized by an extended seasonal sea-ice cover and is considered as a possible source area of the North Pacific Intermediate Water (NPIW). Therefore, reconstructing the characteristics of sediments responding ice melting pulses of the northeastern Asian during the glacial-interglacial cycle is important for studying the past climatic changes and NPIW formation in the northwest Pacific Ocean. We produced the detailed mineralogy of sediments for an IMAGES Core MD012414, which was collected from the central part of the Okhotsk Sea in the Quaternary. The mineralogy of the sediments in the drilling Core MD012414 was analyzed to study the relationship between the climate and sea-ice activity during the Quaternary. Four periods can be abruptly inferred. During the period I, from 0.45 Ma to present, there were five significant terminations and the abundances of minerals oscillated in 100-kyr eccentricity cycles. This was concordant with the global glacial-interglacial cycles resulting from a decoupling of climate condition during late Pleistocene after the MBE (mid-Brunhes event). The period II ranged from 0.9 Ma to 0.45 Ma, which the environment became mediate nutrient suggested by the minor amount of opal and peaking out of calcite at time. This phenomenon may be caused by hydrological change in the Okhotsk Sea and correspond to the strengthened Asian summer monsoon system. Then, the period III was from 1.2 Ma to 0.9 Ma. With hardly determined any calcite and diatom, a cold and severe condition of the Okhotsk Sea was educed. In the period IV, from 1.8 Ma to 1.2 Ma, the trend of opal abundance showed higher values than the former 3 periods, implying an optimum environment in this period. The change from the period IV to III, characterized by high to low productivity, was very likely due to the global mean ice volume increasing event, MPR (mid-Pleistocene revolution).

OKHOTSK SEA, PALEOENVIRONMENTAL CHANGES, QUATERNARY, MBR, MPR

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Late Quaternary variations in atmospheric CO₂ and the oceanic Si fertilization hypothesis: A tropical perspective

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The global C and Si cycles are tightly coupled. In the conventional view, weathering of aluminosilicate

minerals draws down atmospheric CO₂. Dissolved SiO₂ (DSi) is transported by rivers to the oceans, where it is an essential nutrient for diatoms, which utilize CO₂ for photosynthesis. A small fraction of the organic matter and biogenic silica (BSi) produced is eventually buried on the sea floor. This model neglects crucial roles of the continental biosphere in the Si cycle. Land plants greatly accelerate silicate weathering. They actively take up DSi from the soil and deposit it in their tissues as grains of amorphous BSi (phytoliths), which are more soluble than crystalline silicates and may control DSi concentrations in soil water. "Accumulator plants" including grasses, sedges, palms and tropical hardwoods are prolific producers of phytoliths. Stored BSi is released episodically by fires, herbivores, erosion and climate change, while diatoms, sponges and chrysophytes recycle DSi in lakes and rivers. We will explore the possible influence of glacial/interglacial changes in tropical ecosystems on the fluxes of BSi and DSi to the oceans.

SILICA, BIOGEOCHEMISTRY, DIATOMS, PHYTOLITHS, TROPICS

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Long-chain alkenone distributions and temperature dependence in lacustrine surface sediments from China

Qing Sun

Long-chain alkenones (LCK) of lacustrine surface sediments were analyzed in 38 lakes from China. The results obtained were complemented by published data from 13 other lakes in the region. The large temperature and precipitation gradients of the lakes allow for assessment of the temperature dependency of LCK distribution patterns. Different distribution patterns of LCK (C37 predominant pattern and C38 predominant pattern) were detected in the surface samples. The ratio of C37: 4 methyl ketone to the sum of C37 alkenones observed in the different lakes is highly variable (5% to 96%, with mean value of 58%), and more than that seen in marine systems. The finding that some of the ocean LCK precursor algae (*Gephyrocapsa oceanica*, *Coccolithus pelagicus*) were also present in the limnic systems suggested that both systems have similar biosynthetic sources. Empirical relationships between the alkenone unsaturation index Uk'37 and different temperature sets (mean annual air temperatures of different seasons and lake surface water temperatures) were tested. The best correlation between Uk'37 and temperature was obtained using mean annual air temperature (MAAT). A general linear regression of Uk'37 and MAAT can be expressed as $Uk'37 = 0.032T + 0.128$ ($r^2 = 0.83$). Although questions such as species-

uncertainty and other unknown factors for Uk'37 temperature dependence still remain, the equation might be representative of the average contribution of LCK to sediments for these data cover a wide range of surface temperatures water chemistry and different alkenones-producer algal populations. The general relationship of Uk'37 and MAAT is consistent with that in marine systems. It supports previous suggestions that the biosynthetic pathway of alkenones and the mechanism of their temperature signal may be similar in both marine and limnic systems. LCAs could be used as an important paleotemperature proxy in the limnic environment.

LONG-CHAIN ALKENONE, LAKE, CHINA

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Evolving clay mineralogy and trace element composition of the Indus River system

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The Indus River has been influenced by the evolving geology of the western Himalaya since the start of India-Asia collision during the Eocene (~50 Ma), and especially since the building of the Karakoram and Greater Himalaya in Early Miocene time, as well as following their rejuvenation during Pliocene times (~4 Ma). Since the Pliocene the Himalaya have come to dominate the flux, probably due to drainage capture of tributaries away from the Ganges. Terrigenous materials eroded from the Karakoram and Himalaya are ultimately deposited partially in the deltaic region, but mostly in the deep waters of the Indus Fan in the Arabian Sea. Holocene sealevel rise seems to have reduced deep-water sedimentation and increased delta and shelf sedimentation since 18 kyr. Recent coring in the lower Indus deltaic region (around the towns of Thatta, Keti Bander and Badin) shows that eustatic sea-level was an important control on the nature of sediment flux through the river system and into the deep-sea fan. Higher resolution analysis (102-103 yr) including dating of shell material, determination of clay mineralogy, and geochemical studies are now in progress to evolve provenance and weathering regimes, and to see how changes in monsoon strength, linked to Northern Hemispheric deglaciation have evolved since the Holocene.

INDUS RIVER, SEDIMENTS, CLAY MINERALOGY, STRATIGRAPHY, MONSOON STRENGTH

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Millennial-scale variability of Asian monsoon and its impact on Japan Sea paleoceanography

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Oceanographic condition of the Japan Sea, such as surface productivity and deep water convection is strongly influenced by the nature of the inflow through the Tsushima Strait. The nature of the inflow is strongly controlled by the amount of freshwater discharge from Changjiang and other Chinese rivers, which in turn reflects the intensity of the East Asian summer monsoon. Consequently, the variations in East Asian summer monsoon intensity is recorded by various proxies in the Japan Sea sediments. We examined DGC-6 and MD01-2407 cores retrieved from the south-central part of the Japan Sea with temporal resolution of less than 100 years/sample and found millennial-scale variabilities in org-C and carbonate contents that are synchronous with the Dansgaard-Oeschger cycles within the error of ^{14}C dating. We also found that similar millennial-scale variabilities are persisted in Holocene although amplitudes became smaller. It seems that persistent teleconnection exists between Greenland and East Asia throughout the last glacial-interglacial cycle probably through atmospheric circulation.

JAPAN SEA, ASIAN MONSOON, DANSGAARD-OESCHGER CYCLES, HOLOCENE, TELECONNECTION

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Records of paleoclimatic change from Tswaing crater lake, South Africa

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Our understanding of paleoclimatic change remains limited by a lack of long-term terrestrial records from the southern hemisphere. In particular, the relative influence of changes in direct insolation and changes

in boundary conditions associated with glacial-interglacial cycles remains poorly understood. Tswaing crater lake is one of the few sites that can provide such information, because it contains a continuous sediment record that covers at least the last two glacial-interglacial cycles. Two 90-m-long sediment cores were obtained from the lake in November 2000. A chronology for these cores has been constructed using seven radiocarbon dates from a core obtained in 1988, and six U/Th dates on carbonates from the new cores. U/Th measurements were obtained using TIMS, and isochrons were used to correct for the presence of detrital material. Preliminary results indicate that the sedimentary record covers approx. the last 300 ka. Records of sediment composition, the isotopic values of authigenic carbonates, the composition of organic material, and diatom assemblages have been used to produce paleoclimatic records. The response of these proxies to climatic forcing depends on paleohydrological conditions, and these must therefore be considered before paleoclimatic conditions can be reconstructed. Preliminary results indicate that precessionally driven changes in insolation at 25°S affected evaporation from the lake during the dry winter months. Changes in boundary conditions associated with glacial/interglacial shifts also appear to have affected climate in the region, however, and it is proposed that these changes are the result of variations in sea-surface temperatures and atmospheric circulation.

AFRICA, PALEOCLIMATE, PALEOHYDROLOGY, PRECESSION, BOUNDARY CONDITIONS

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Quaternary upper ocean thermal gradient variations in the South China Sea: Implication of East Asian monsoon climate

Jun Tian, Pinxian Wang, Ronghua Chen, Xinrong Cheng

The East Asian monsoon climate represents an overwhelming influence on local climatic conditions of the South China Sea (SCS). Here, we present results from a three-year study of modern sediment traps from

the central SCS in which the opal%, fluxes of *Pulleniatina obliquiloculata* and *Globigerinoides ruber*, organic carbon flux and primary productivity, all show highest values during winter when the mixed layer depth is deepest. The $\delta^{18}\text{O}$ difference ($D\delta^{18}\text{O}$ (P-G)) between the subsurface *P. obliquiloculata* and the mixed layer *G. ruber* in core top samples from 12 piston cores and one Ocean Drilling Program (ODP) site in the SCS is large in a cold eddy area with a shallow mixed layer zone off Vietnam, but smaller from a deep mixed layer zone at settings lacking cold eddies. We also present 1.56 Myr isotope records of *G. ruber* and *P. obliquiloculata* from ODP Site 1143 in the southern SCS that reveal upper ocean thermal gradient variations during the Quaternary. Lower $D\delta^{18}\text{O}$ (P-G) values indicate increased mixed layer depths over most glacial episodes likely due to stronger winter monsoon winds, and higher $D\delta^{18}\text{O}$ (P-G) values during interglacial intervals suggest decreased mixed layer depths and thus weaker winter monsoon winds. Comparison of $D\delta^{18}\text{O}$ (P-G) with *P. obliquiloculata*% at Site 1143 and herb% and opal flux at Site 1144 demonstrate that glacial-interglacial variations were strongly influenced by stronger and weaker east Asian winter monsoons during glacials and interglacials respectively. Therefore, the upper ocean thermal gradient variations in the SCS have been consistently affected by the East Asian winter monsoon since at least the beginning of the Pleistocene.

SOUTH CHINA SEA, THERMAL GRADIENT, EAST ASIAN WINTER MONSOON

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Marine carbonate dissolution record during the Eocene-Oligocene transition, the Walvis Ridge transect, South Atlantic

Shouting Tuo, Zhifei Liu, Quanhong Zhao, Xinrong Cheng, Wei Huang

The most prominent cooling event of the Earth surface in the Cenozoic during the long-term transition from a "green-house world", to an "ice-house world", is the Earliest Oligocene Glacial Maximum (EOGM), immediately following the Eocene-Oligocene (E/O) boundary at about 33.7 Ma. This study analyzed planktonic and benthic foraminiferal oxygen and carbon isotopes, carbonate content, coarse fraction, planktonic foraminiferal fragmentation, benthic foraminiferal percentage, and carbonate dissolution proxy constructed by grain size measurement in samples from deep-water sites 1262, 1263 and 1265,

Ocean Drilling Program (ODP) Leg 208 on the Walvis Ridge, South Atlantic. The results show that the earliest Oligocene $\delta^{18}\text{O}$ values represent the magnitude of continental ice sheets on east Antarctica and indicate a large decrease in both surface and deep water temperatures of worldwide oceans during 33.5-33.1 Ma. The carbonate dissolution proxy constructed by grain size measurement of carbonate ooze at ODP Sites 1263 and 1265 has a good correlation with traditional carbonate dissolution proxies. The $\delta^{13}\text{C}$ records show a large positive excursion during the EOGM and indicate some type of shift in global carbon reservoir, probably a sudden increase in organic carbon burial rates by absorbing inorganic carbon dissolved in sea-water, causing atmospheric pCO_2 decreasing. The calcium carbonate pump could transport the atmospheric CO_2 into the deep sea, and could transform atmospheric carbon to sedimentary carbon. This process likely had caused the rapid cooling at EOGM and a magnificent sea-level fall, leading to the first permanent ice sheet on the eastern Antarctica.

EOCENE, OLIGOCENE, CARBONATE DISSOLUTION, SOUTH ATLANTIC, OCEAN DRILLING PROGRAM (ODP)

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Use of the Index of Similarity for the assessment of fossil spore-pollen spectra

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With the purpose of assessing fossil spore-pollen spectra (SPS) the author has introduced an absolutely new criterion - an Index of Similarity. This criterion allows an objective connection to be expressed between fossil SPS components and corresponding components of modern surface samples. The Index of Similarity can be calculated for any taxon of fossil SPS, provided the research of sediment samples, surface samples and modern vegetation is carried out in conjugation. This index is calculated with the formula: $X/Y = I_s$, where: X is the percentage content of pollen and spore of any taxon in the composition of a fossil SPS sample; Y is the percentage content of the same taxon in the composition of a recent SPS sample; I_s is the Index of Similarity. In the numerical form it is a decimal fraction, expressed in the following way: $I_s \geq 0$; graphically it is a point with the coordinate axes. The Index of Similarity graphs are then built on the basis of the data obtained from calculations with the use of the above formula. Such graphs are more

informative, compact and more obvious than traditional spore-pollen diagrams. The introduced index allows to make an assessment of fossil SPS on the zonal and coenotic levels. The use of the Index of Similarity helps to reconstruct paleogeographic phenomena and events in time and in space with more confidence, and, consequently, to make a better correlation of sediment sequences, containing fossil SPS. We suppose that this index can also be used in the diatom analysis, in the foraminifer analysis and in the study of other groups of organisms.

FOSSIL SPORE-POLLEN SPECTRA, HOLOCENE, SIMILARITY INDEX, RECENT AND PAST ENVIRONMENT

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Paleoclimatic record from a limnic sequence from south-eastern France: Magnetostratigraphy and chronology

Daniel Veres, Nicolas Thouveny, Barbara Wohlfarth, Linda Ampel, Frank Preusser, Anne Hormes, Göran Possnert, Siwan Davies

Here, we present preliminary results from an ongoing paleo- and rock magnetic investigation of two new long sedimentary cores from the paleolake of Les Echets, France. The work is part of a larger project dedicated to the definition of the timing and impacts of Dansgaard-Oeschger cycles on the continental area of Western Europe during OIS 3 and 2. The magnetic data set comprises a high-resolution record of magnetic susceptibility, ARM, IRM, SIRM, HIRM and S-ratios. The chronology is based on a high density population of AMS ^{14}C ages and on OSL ages. Normalized NRM, a proxy of the relative paleointensity (RPI) and paleomagnetic inclination were also employed to track the variations of the geomagnetic field, namely to locate the occurrence of paleomagnetic excursions such as the Mono Lake excursion dated at 32 ka BP. The sediment samples mostly consist of an alternation of massive clayey silts and highly compacted gyttja horizons, which produce a detailed signature of the magnetic properties. Organic carbon, grain-size and gamma-ray density display similar variations, indicating a millennial-scale oscillatory pattern of cyclic shifts from glacial to interglacial conditions. In terms of environmental reconstruction, this probably reflects 1) a balance between dominant catchment erosion during cold stadials and soil development during temperate interstadials, 2) lake level variations, 3) low/high lake organic production. A comparison of our chronology with North Atlantic marine and ice-core records indicates that the region experienced major environmental changes between 60-15 ka BP, very likely associated to Dansgaard-Oeschger climate variability.

PALEOCLIMATE, PALEOMAGNETISM, GEOCHRONOLOGY, LAKE SEDIMENTS, DANSGAARD-

OESCHGER CYCLES

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Mixed layer characteristics in the eastern Gulf of Cadiz during Dansgaard-Oeschger Interstadials 6-11

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In the eastern North Atlantic, the subsurface layer is formed by North Atlantic Central Water (NACW), which is upwelled off Portugal and in the Gulf of Cadiz entrained into the Mediterranean Outflow Water. To study subsurface variability in the Gulf of Cadiz, we generated multi-species stable isotope records for the interval of Dansgaard-Oeschger (DO) interstadial (IS) 6 to 11 (33-43 kyr BP) in core MD99-2339. Surface layer conditions are reflected by *G. bulloides* and *G. ruber white*, conditions down to 400 m by *G. inflata* and *G. truncatulinoides*. With the exception of IS 8, $\delta^{18}\text{O}$ values of *G. ruber* are 0.2-0.3‰ lighter than those of *G. bulloides*, most probably reflecting different growth seasons rather than temperature gradients. The $\delta^{18}\text{O}$ records of the deeper dwelling species reveal DO cyclicity, but with values that are 0.5 to 1.5‰ heavier and imply a surface to sub-surface temperature gradient of 1-6°C. During stadials, at the beginnings of IS 10 and 7 and during most of IS 8 *G. inflata* and *G. truncatulinoides* have similar $\delta^{18}\text{O}$ values, but during the rest of the IS *G. inflata* deviates by about -0.4‰. Lighter $\delta^{18}\text{O}$ in *G. inflata* is contemporary with $\delta^{13}\text{C}$ depletion indicating nutrient maxima in the deep winter mixed layer. So while *G. truncatulinoides* seems to record the more stable conditions in the NACW, *G. inflata* appears to indicate that the penetration depth of the deep winter mixing changed from IS to IS and even in the course of an IS.

PALEOCEANOGRAPHY, DANSGAARD-OESCHGER CYCLICITY, MARINE ISOTOPE STAGE 3, PLANKTONIC FORAMINIFERA

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High-resolution paleoceanographic and paleoclimatic records in the Bering Sea over the last 100,000 y BP

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Four piston cores were retrieved from the Bering Sea during the First and Second Chinese National Arctic Expeditions, respectively. Percentage investigations of *Cycladophora davisiana* (Radiolaria, Protozoa) in the cores show that the millennial scale Younger Dryas and Bølling/Allerød events, Heinrich and Dansgaard-Oeschger events, recorded by *C. davisiana* are distinguished from the two cores. *C. davisiana* event a, b, c, d and e, respectively, corresponding to marine isotopic stage 1, 2, 3, 4 and 5 are identified from the other two cores. High-resolution records of *C. davisiana* in four cores are tuned to the oxygen isotopic records in GISP 2 and SPECMAP and the depth-age frameworks are established, supplying a stratigraphic base for paleoceanographic and paleoclimatic studies over the last 100,000 y BP. Variations of biogenic opal and organic carbon in the cores indicate that surface productivity increased during the warm intervals, deglaciation and interglacial periods and decreased during the cold intervals and glacial periods. High ice-rafted detritus and charcoal grains during the cold intervals, deglaciation and glacial periods imply the sea ice extension in the Bering Sea and dry and cold climate in Interior Alaska.

CYCLADOPHORA DAVISIANA, BERING SEA, MILLENNIAL SCALE, SURFACE PRODUCTIVITY, SEA-ICE EXTENSION

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The connotation and significance of Sanmen formation

Shubing Wang, Fuchu Jiang

Lacustrine deposits of the ancient Sanmen Lake have been preserved in good condition in the Huangdigou profile, which is located north of the Sanmenxia Reservoir in Pinglu County of Shannxi Province. From a magnetostratigraphy and Optically Stimulated Luminescence (OSL) dating it is known that sediment deposition started in the middle of the Gilbert reverse polarity chron about 5 Ma BP, and ended in the late Brunhes normal polarity chron around 150 ka BP. Since the depositions belong to the ancient Sanmen Lake, and according to lithostratigraphic principles, it is referred to as Sanmen Formation. Based on the lithological characteristics, the sequence can be subdivided into three units, the upper unit consisting dominantly of sand layers, the middle unit of clay layers and the lower unit of basal gravel. This sediment sequence is now known to comprise the longest period of deposition, commencing earlier and terminating later than any other sequence in the region.

later Cenozoic, Sanmen Formation, magnetostratigraphy, Sanmenxia Reservoir, Yellow River

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Palynological records since the Last Glacial Maximum in the Xunta Shelf of the South China Sea

Xiaomei Wang

Here, we present pollen and spore data from sediments of Station 18323 from the continental shelf of the Southern South China Sea. The 5.4 m long profile covers the last 31,000 years, including the late stage of Marine Oxygen Isotope Stage 3. The study reveals that before the Last Glacial Maximum, lowland rainforest covered the emerged southern continental shelf of the South China, and at the Last Glacial Maximum lowland rainforest diminished and Herbaceae expanded on the adjacent islands. This indicates cooling and dryness at the Ice Age. During the Termination and the Holocene, expansion of mangroves and lowland rainforest shows warming of the climate, rising of the sea level and the submergence of the shelf.

SUNDA SHELF, POLLEN, SPORES, VEGETATION, TEMPERATURE

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A 50-ka Pb-isotope record from the southern hemisphere - Lynch's Crater, Queensland, Australia - and its implications for climate change

Raphael Wust, Malin Kylander, Raquel Garcia-Sanchez, Joanne Muller, Dominik Weiss

Lead isotopes in peat and sediment deposits are usually utilized to determine the source of lead. A study for example from Asia Pacific demonstrated that despite major weathering and climate changes over the past 12 Ma, the ultimate source of dust, and hence isotopic composition of the eolian fraction to the north Pacific, did not change. On the other hand, several European peat deposits have demonstrated that Holocene Pb-isotopic compositions were much less radiogenic (lower 206/207 ratios) than the Pleistocene background or pre-anthropogenic values and concluded that both climate change and anthropogenic activity changed markedly the global Pb-isotopic signature. Here, we present the first Pb-isotopic record from the southern hemisphere from tropical NE-Australia covering the past 5-50 ka. The record shows that Pb flux was low until about 34 ka and increased rapidly about 3.5 fold until 24 ka. Then, after a short period of low flux, Pb flux increased slowly over the next 13 ka and culminated at about an 8-fold increase around 10-11 ka before it decreased to values just before 24 ka. The record also shows that the Holocene values were in general less radiogenic than the Pleistocene ones, but several events occurred during the Pleistocene that led to the deposition of less radiogenic material at Lynch's Crater, one of them coincides with the timing of H4. Because some of these changes are rapid, it is possible that short-time changes such as volcanic eruptions with significant different Pb-signature contributed dust to the peat deposits where three sources are identified. In general, dust influx and composition changes were most likely the result of changes in regional precipitation and thus vegetation coverage in combination with regional (NE-Queensland, SE-Asia) volcanism rather than global climate changes.

Pb-ISOTOPES, Pb-FLUX, SOUTHERN HEMISPHERE, PEAT DEPOSIT, CLIMATE CHANGE

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Late Holocene high-frequency East Asia Winter Monsoon variability inferred from environmentally sensitive grain size components in the distal mud area, East China Sea

Rong Xiang, Zuosheng Yang, Zhi-gang Guo, Yoshiki Saito, Dejiang Fan

Environmentally sensitive grain-size component (ESGSC) extracted from grain-size data of a composite sediment core B2, which were retrieved from the distal mud area, East China Sea (ECS), can be used to indicate the variations of East Asia Winter Monsoon (EAWM), with high(low) content/mean-size of ESGCS denote to strong (weak) EAWM. Combined with AMS ¹⁴C dating the composite B2 record provide a continuous high-resolution of EAWM changes over the past 2500 years, with an average resolution of 10 years. The results show that the variations of EAWM are consistent with temperature changes inferred from historical documents in eastern China over the past 2500 years, from which four climate stages may be identified. In stages before 1900 yr BP and 1450-780 yr BP the EAWM were comparatively weak, corresponding to warm climate periods in eastern China, respectively. And in stages of 1900-1450 yr BP and 780-219 yr BP the EAWM were strongly developed, which correspond well to climate changes of two cold periods in eastern China. It is also showed from this study that the stage at 780-219 yr BP was the coldest climate period during the last 2500 years and could be, therefore, related to the Little Ice Age (LIA). Cross-spectral analyses between proxies of ESGSC and $\Delta^{14}\text{C}$ measured in tree rings show typical periodicities of 258, 55, 40, 26, 24 and 22 years, indicating solar forcing was the main driving force for EAWM changes during this period.

EAST CHINA SEA, EAST ASIA WINTER MONSOON, ENVIRONMENTALLY SENSITIVE GRAIN-SIZE COMPONENT, MUD AREA, LATE HOLOCENE

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2000 years methane record in a high altitude Himalayan ice core and its relationship with climate change

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A high-resolution Himalayan ice core record shows an obvious CH₄ concentration increase in the low-mid latitude since industrialization, and reveals similar trend of methane concentration fluctuation with the polar region records. The high degree of detail of the record over the last century allows revealing a significant period between the two World Wars when the anthropogenic CH₄ increase was put to a halt. This sub-tropical CH₄ record also allows quantify for the first time the difference of CH₄ mixing ratio between polar and sub-tropical latitudes during pre-industrial time. The average CH₄ concentration in the record from the Dasuopu ice core is 782 ppbv in the time interval of 0~AD 1850, and the maximum temporal variation exceed 220 ppbv which has never been found in polar ice records. The average difference is 66 ppbv with Greenland and 107 ppbv with Antarctica. The record suggests that the tropical latitudes might represent as much of the global CH₄ sources in pre-industrial time. In addition, the temporal fluctuation of the pre-industrial CH₄ records suggests that Monsoon evolution incorporated with high CH₄ input in the south Asia might be responsible for the relatively high CH₄ concentration observed in the Dasuopu ice core around AD 1500~1600. With the Monsoon retreated in Little Ice Age corresponding extraordinary low atmospheric CH₄ concentrations (the minimum is 658 ppbv), even lower than Antarctica contemporaneous records.

HIMALAYAN ICE CORE, METHANE RECORD, CLIMATE CHANGE

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Paleo-temperature seesaw in the mid-latitude North Pacific during the last 150 kyr

Masanobu Yamamoto

The late Quaternary records of alkenone sea surface temperature (SST) in the Japan (Core MD01-2421) and California margins (ODP Sites 1014 and 1016) showed orbital-scale anti-phase SST variations between the two margins during the last 150 kyr. This east-west seesaw-like change agreed well with the long-term El

Niño-Southern Oscillation (ENSO) behavior predicted by the Zebiak-Cane ENSO model as regards both the timing and frequency during 0-60 ka and 120-145 ka, and is attributed to the precession-controlled change in tropical ENSO behavior. Extreme conditions (ENSO-like SST pattern observed during strong El Niño) appeared during the last two deglaciations. This extreme condition is attributed to both the strong cooling in the Kuroshio-Oyashio transition zone and the early warming of the California Borderland during deglaciations. The cooling at the Japan margin was a result of the stronger summer Okhotsk High, which was likely enhanced by the heating of the land surface of northeastern Siberia. The early warming at the California Borderland was a result of the weaker summer North Pacific High, which was likely declined by the earlier warming of the North Pacific than ice-covered North American continent. Difference in the responses of the land, ocean and ice surfaces to a greenhouse gas forcing was a most likely cause of the strongly El Niño-like SST pattern in the North Pacific during the last two deglaciations.

PACIFIC, SST, DEGLACIATIONS, PRECESSION, ENSO

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Evolution of the Changjiang in relation to the Tibetan Plateau uplift: Geochemical constraints of Quaternary sediments in the Changjiang Delta

Shouye Yang

The Changjiang evolution in Quaternary and its response to the Tibetan Plateau uplift remains poorly understood as compared to other Asian rivers originating from the Himalayan-Tibetan Plateau. Here, we use elemental and Sr-Nd isotopic compositions as well as monazite age spectrum, to identify the sources of the Quaternary sediments (Core PD) in the Changjiang Delta. Elemental ratios such as Nb/Co, Th/Co and Ti/Co are more enriched and variable in the Neogene sediments than in the overlying Quaternary sediments, whereas Cr/Th shows the opposite variation trend, suggesting that the Neogene sediments were sourced from more mafic provenances whereas the Quaternary sediments came from more felsic sources. The Eu anomaly and Sr-Nd isotopic compositions also show distinct changes at the Neogene/Quaternary boundary. These changes together indicate that more mafic components joined in the river during the early Quaternary. We propose that the Changjiang River developed from a small river in the east and did not reach the Emeishan area until the early Quaternary, but this river extended to the west, draining the Emeishan area at the early Quaternary. Such a drastic change was possibly a result of the phased uplift of the Tibetan Plateau, which resulted in the incision of the Three Gorges and allowed detritus from the Emeishan basalts to be transported to the Changjiang. Our preliminary data imply that the Changjiang might

be formed in the early Quaternary, and not a very young (~150 ka BP) or old river (Cretaceous-early Tertiary) as suggested by previous studies.

CHANGJIANG, EVOLUTION, QUATERNARY, SEDIMENT, TIBETAN PLATEAU

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Late Pliocene palynological assemblages from the ODP Site 798B, East Sea (Japan Sea): Implications for vegetation and climatic history

Sangheon Yi, Young-Joo Lee, Dong-Yoon Yang, Ju-Yong Kim

The palynological study from the selected intervals (Section 30X-31X, 280.0-296.73 mbsf) of core drilled in ODP Leg 128, Site 798B on Oki Ridge within the Yamato Basin, East Sea (Japan Sea) provide a consistent pollen stratigraphy and a solid basis for regional paleoenvironmental reconstructions, such as paleovegetation and Asian monsoon climate, during the Late Pliocene. High diverse and abundant terrestrial spore-pollen and marine dinoflagellates were yielded in this interval. Of the sporomorphs, conifers of *Pinus* and *Taxodiaceae-Cupressaceae* and cool-temperate representatives, *Fagus* and *Quercus* (*Lepidobalanus*) predominate throughout the interval indicating cold, dry climatic conditions. High-resolution pollen analyses allow recognition of well-known episodes of climate evolution (development of major northern hemisphere glaciation and of mixed conifer-deciduous forest at 2.5-2.3 Ma), as well as now insights into climate dynamics such as occurrences of short, warm excursions and of unstable periods. Moreover warm-water dinoflagellate species, *Impagidinium paradoxum*, *Lingulodinium machaerophorum* *Selenopemphix* cf. *conicum* and *Tuberculodinium vancampoae*, can reflect the development of Tsushima Warm Current in the East Sea (Japan Sea) during the glaciation period. Finally the studied interval section was dated to be Late Pliocene based on *Filishaera pilosa* of dinoflagellate that was recovered from Late Pliocene marine sediments in the Western Pacific Ocean.

PALYNOLOGY, ODP SITE 798B EAST SEA (JAPAN SEA), VEGETATION, CLIMATE, LATE PLIOCENE

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Seasonal variation of water mass structures in Marian Cove, northern Antarctic Peninsula

Kyu-Cheul Yoo, Ho Il Yoon

The seasonal variation of the water mass properties in the southern South Shetland Islands is greatly affected by the circulation patterns of the Antarctic Circumpolar Current (ACC) in the northern Antarctic Peninsula (AP). By the relations among temperature, salinity and DOC, two distinct water masses were identified at Marian Cove. These are warm/fresh summer water from the eastern Bellingshausen Sea and cold/dense winter water from the Weddell Sea. Warm/fresh summer water found from the mid austral summer to the early autumn. The characteristics of temperature and salinity matched well with that of the southern ACC regime prominent within Drake Passage in the early austral summer. This suggests that the southernmost boundary of the ACC shifted poleward during austral summer period. In addition, the poleward movement of the ACC regime in austral summer may cause a regional warming trend of the AP.

ANTARCTIC PENINSULA, REGIONAL WARMING, ACC, WATER MASS, CTD

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Glaciomarine sedimentation and its paleoclimatic implications on the West Spitsbergen Fjord (Isfjorden) over the last 15,000 years

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Analyses of sedimentological and geochemical parameters from radiocarbon-dated sediment cores retrieved from the central parts of Isfjorden, West Spitsbergen reveal a detailed paleoclimatic and/or paleoceanographic history over the last 15,000 radiocarbon years. The overconsolidated diamicton at the base of core JM98-845-PC is supposed to be a basal till deposited during the Last Glacial Maximum. Deglaciation of the fjord commenced since the glacial maximum, marked by the deposition of interlaminated sand and mud in the ice-proximal zone, and lasted for about 4000 years with decreasing C/N ratio. A return to colder conditions occurred at around 10,800 yr BP with a drop in TOC content, which is probably coincident with the Younger Dryas event in the North Atlantic region. At this time, an abrupt increase in percentage of TOC content as well as a decrease in C/N ratio suggests increased terrigenous input due to the glacial advance. A climatic optimum is recognized between 7800 and 2400 yr BP, coinciding with a 'mid-Holocene climatic optimum' from several other northern hemisphere

sites, e.g., the Laurentide Ice sheet. During this time, as the glacial system receded from the fjord, enhanced primary productivity occurred in open marine conditions, resulting in the deposition of organic-enriched pebbly mud with evidence of TOC maxima and C/N ratio minima and causing post-depositional dissolution of calcium carbonate component in sediments. Around 2400 yr BP (the onset of Neoglacial), pebbly mud characterized by a decrease in TOC as well as an increase in sand content, reflects the formation of more extensive and seasonally persistent sea ice, which might cause increased terrigenous input, as evidenced by an increase in C/N ratio. Our results provide evidence of climatic change on the West Spitsbergen fjords that helps to refine the existence and timing of late Pleistocene and Holocene millennial-scale climatic events in the northern hemisphere.

NORTHERN HEMISPHERE, HOLOCENE,
PALEOCLIMATE

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Late Quaternary sedimentary processes in the northern continental margin of the South Shetland Islands, West Antarctica

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Sedimentary facies and high-resolution (3.5 kHz) echo facies were analyzed to elucidate sedimentation pattern of the late Quaternary glaciomarine deposits in the northern continental margin of the South Shetland Islands, West Antarctica. Six sedimentary facies are classified, based on grain texture and sedimentary structures in gravity cores. The high-resolution echo characters are classified into 6 echo facies on the basis of clarity, continuity, and shape of bottom and sub-bottom echoes together with seafloor topography. Distribution of the echo and sedimentary facies suggest that a large part of the continental margin deposits formed during the Last Glacial Maximum (LGM) and subsequent glacier-retreating period. When the grounded glaciers extended to the present shelfbreak during LGM, coarse-grained subglacial tills were widespread in the shelf area, and deep troughs in the shelf were carved beneath the fast-flowing ice stream. As the glacial margin retreated landward after LGM, dense meltwater plumes released from the retreating ice-front were funneled along the glacier-carved troughs, and accumulated channel- or canyon-fill deposits in the shelf and the upper to mid slope. At this time, some upper slope sediments seem to have been rarely reworked by slope failures and contour currents. After the glacial retreat, sediments in the shelf and slope areas have been mainly introduced

by persistent (hemi) pelagic settling, and fine-grained turbidity currents frequently occur along the axis of the South Shetland Trench.

ANTARCTICA, QUATERNARY, GLACIOMARINE
SEDIMENTATION, SEDIMENTARY FACIES, ECHO FACIES

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A La Niña-like condition in the Eastern Equatorial Pacific during MIS 13-15

Pai-Sen Yu, Min-Te Chen

The Eastern Equatorial Pacific is a critical region because sea surface temperature (SST) in this region is sensitive to changes in upwelling and ocean circulation, and is therefore indicative of intensive air-sea interaction that drives global climate change. Site 1240 (0°1.311'N; 86°27.758'W; WD: 2,921 m) cores taken from the ODP Leg 202 is ideal to record changes in upwelling and biological production, as well as long-term changes in upper-ocean temperature and pycnocline depth in the Eastern Equatorial Pacific. One of our objectives in the paleoceanographic reconstructions is to better understand how tropical oceans interact with global climate over orbital timescales, and focus on testing hypotheses of ENSO-like oscillation and of extra-tropical forcing prevailed in long-term climate variations in the tropics. We are especially interested in examining an abnormally "warm and wet" climate in glacial MIS 14 shown in Chinese loess and South China Sea marine records and looking for any tropical origin of forcing or feedback for explaining the abnormality. Our record provides an excellent opportunity to compare multiproxy planktic foraminifer assemblages, Mg/Ca and alkenone records, as it is located above the lysocline, therefore minimizing the effect of dissolution on Mg/Ca in foraminifera. Our observations indicate that larger cooling estimated by different faunal foraminiferal transfer function (~5-7°C) of MIS 14 is similar with those previous studies during the LGM-Holocene. Our studies suggest large temperature and humidity gradients existed in MIS 14 and possibly more persistent La Niña-like conditions in the glacial equatorial Pacific climate.

EASTERN EQUATORIAL PACIFIC, SEA SURFACE
TEMPERATURE, LA NIÑA-LIKE

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Mg/Ca and $\delta^{18}\text{O}$ in benthic foraminiferal calcite: Core top calibration and carbonate concentration effect

Jimin Yu, Henry Elderfield

Mg/Ca and $\delta^{18}\text{O}$ in foraminiferal shells have been widely used for reconstructing past seawater temperature and salinity changes. In this study, Holocene sediment core tops from around the world's ocean have been used for measurements of paired Mg/Ca and $\delta^{18}\text{O}$ in three benthic species (*Cibicidoides wuellerstorfi*, *Cibicidoides kullenbergi* and *Uvigerina* spp.). When only samples from carbonate saturated environments are considered, Mg/Ca in *Uvigerina* spp. exhibit similar temperature dependence sensitivity to those in planktonic foraminiferal shells (Anand et al., 2003). In contrast, Mg/Ca in *C. wuellerstorfi* and *C. kullenbergi* are more temperature sensitive at the range of 0-6°C and *C. wuellerstorfi* from the Nordic Seas exhibit exceptional high Mg/Ca values. When $\Delta\text{CO}_3^{2-} < 0$, samples fall below the calibration lines and $\Delta\text{Mg/Ca}$ are positively correlated with ΔCO_3^{2-} , indicating post mortem dissolution effect on Mg/Ca in foraminiferal calcite. The $\delta^{18}\text{O}$ -temperature relationship for *Uvigerina* spp. corroborates the equation of Shackleton (1974) while $\delta^{18}\text{O}$ in *C. wuellerstorfi* and *C. kullenbergi* agree with the relationship given by McCrea (1950) between -1~4°C. Our data demonstrate a negligible carbonate concentration effect on oxygen isotopes which has been documented for inorganic calcite (e.g., Zeebe, 1999) and planktonic foraminifera (e.g., Spero et al., 1997).

CARBONATE GEOCHEMISTRY, BENTHIC FORAMINIFERA, DEEPWATER CHEMISTRY, CORETOP CALIBRATION

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Geological hazards of coral reefs in the southern South China Sea

Wenhuan Zhan

Here, we analyze the basic characteristics and distribution regularity of geological hazard factors of coral reefs in the southern South China Sea (SCS), according to information from seismic profiles and the seabat-8111 multibeam system. Geological hazards of coral reefs as a new research field of modern engineering geology is developing under the necessity of coral reef construction, will bring advancements to the classical soil mechanics theory, and has strategic significance and great potential for applications. With the development of ocean resources, coral reefs are becoming more and more important. The types of coral reef constructions urge us to research on the geological

hazard properties of coral reefs. Here, we introduce the concept of the geological hazards of coral reefs. And at the same time, the human activity influences on coral reefs are discussed for the studied region. This study is supported by the National Natural Science Foundation of China (Grant 40476026) the Guang Dong Natural Science Foundation (Grant 04001309).

HAZARDS, CORAL REEF, SOUTHERN SOUTH CHINA SEA

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Ocean feedbacks on the Afro-Asian summer Monsoon during the Mid-Holocene

Yan Zhao, Olivier Marti

Within the framework of the PMIP (Paleoclimate Modelling Intercomparison Project), we investigated the role of the ocean circulation in mid-Holocene climate simulations from several coupled ocean-atmospheric general circulation models (OAGCMs). The analyses focus on the tropical circulation and the Afro-Asian monsoon. Comparisons with atmosphere alone simulations (PMIP1) show that the ocean feedback acts both on the length and the magnitude of the summer monsoon. In particular, all coupled simulations produce a delayed retreat of the Indian summer monsoon. This phenomenon involves a positive local air-sea interaction. Another feature is a dipole-like SST anomaly over Atlantic Ocean that contributes to induce more moisture from ocean to North Africa and then increases precipitation there. Our analyses indicate that the dipole-like structure is, to first order, the response to orbital change. However, the wind-evaporation-SST mechanism and Ekman transport over the northeastern tropical Atlantic also play a role. Analyses of interannual variability of Afro-Asian summer monsoon precipitation are also presented here. New simulations with interactive vegetation will be available as part of PMIP2. We will also discuss the relative strength of ocean and vegetation feedback on monsoon activity and ocean feedback.

MONSOON, MID-HOLOCENE, OCEAN FEEDBACKS

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Session 4: Climate, Humans and the Environment in Asia

This session zooms in on various regions in and around the host country of the meeting. The ensemble of numerous local studies composes detailed pictures on regional aspects of climate change. Many contributions in this session extend towards addressing the human dimension of regional environmental change, an issue of particular importance given the dense and dynamic population in many parts of Asia. Papers cover various timescales and are grouped into regional focus groups.

Plenary Lectures: *p. 114 - 118*

Poster Abstracts: *p. 119 - 174 (arranged by first author alphabetically)*

First Author Index: *p. 176 - 179*

The role of the Indo-Pacific Warm Pool on global climate change during the Quaternary

Patrick De Deckker

Tropical oceanic water that surrounds Southeast Asia and northern Australia today is characterized today by constantly high (>28°C) sea-surface temperatures [SST], and a low-salinity and shallow 'cap' [= barrier layer] that prevents much exchange between the deeper ocean and the atmosphere. This region, called Warm Pool, sees the formation of high convective clouds that are critical to climate forcings on either sides of the Pacific and Indian Oceans. Today, the Warm Pool is the location of vast amounts of moisture and heat exchange between the atmosphere and the oceans, with ensuing contrasting monsoonal climates that affect the bordering land masses and its people and biota. Any slight change in SST in the Warm Pool, and/or a change in the ocean to land ratio - the latter resulting from cyclic sea level changes so typical of the Quaternary - can have substantial consequences for climate, very likely on a global scale. A reduction in deep convective clouds over the Warm Pool would engender the following: (1) increase the radiative loss to the upper atmosphere, thus causing its cooling, but also force sea-surface heating associated with strong diurnal temperature contrasts on land; (2) change the precipitation/evaporation over the Warm Pool region and associated landmasses, and also change the moisture of the upper atmosphere; (3) destabilize the upper layers of the oceans, and alter the freshwater flux to the global ocean; (4) alter wind regimes, their strengths and patterns in the region; (5) alter the poleward transport of heat and moisture, thus affecting the characteristics and formation of oceanic deep water, and lapse rates in the tropics; and (6) the albedo ratio between land and ocean. In summary, the Warm Pool is the Planet's HEAT ENGINE, and I will argue that subtle changes in SST occurred in this region during the Quaternary that were critical for global climate.

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Millennial-centennial-scale climate variability of the low latitude Western Pacific during the Late Quaternary

Zhimin Jian, Xinrong Cheng, Laibin Jiang, David Lea, Wolfgang Kuhnt

Present-day climate is affected significantly by the Western Pacific Warm Pool (WPWP), bounded approx. by the 28°C surface isotherm, through El Niño-Southern Oscillation (ENSO) phenomena. Here, we present a high-resolution record of sea surface temperature (SST) and depth of thermocline (DOT) in the WPWP at centennial timescale for the last 240 kyr, reconstructed from two sediment cores based on planktonic foraminiferal fauna and their stable isotopes, as well as detailed AMS ¹⁴C datings. It has been found that the SST and DOT changed significantly with the amplitudes of ~3-4°C and ~60-80 m respectively, indicating the climatic instability of the WPWP during the late Quaternary. However, the changes of subsurface water were larger than those of surface water, and these changes mainly took place in the Pacific rather than the Indian side. There was intensified DOT contrast between the equatorial Western Pacific and Eastern Indian during the Holocene rather than during the glacial stage, which hence resulted in weaker Indonesian Throughflow and stronger El Niño during glacials. It is interesting that the difference ($D\delta^{18}O$) between the oxygen isotope of thermocline-dwelling species *Pulleniatina obliquiloculata* and mixed-layer-dwelling species *Globigerinoides ruber*, as a proxy of the DOT change, clearly displays dominant semi-precessional cycles and millennial/centennial-scale fluctuations, which center at periodicities of ~1.17 kyr and ~1200 yr, ~700-900 yr, ~500 yr, and ~200 yr, and exist throughout the glacial, deglacial and postglacial stages, even though such short-term climate variability is dominated by centennial-scale cycles in non-glacial sections, instead of millennial-scale cycles in their glacial cousins. Particularly, the timing of the tropical Pacific Mg/Ca-based SST change is similar to the timing of the atmospheric CO₂ change, and a little bit ahead of the $\delta^{18}O$ change during the last deglaciation. This study further suggests that the WPWP plays an important role in global climate changes on millennial/centennial and orbital timescales through ENSO-like systems.

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The evolutionary process of Asian dust and its role for the Earth System in the past

Zhisheng An

Records of dust deposition in the past may be used to evaluate global iron connections under different conditions from today. Dust production, ocean paleoproductivity, $p\text{CO}_2$ and past climate have co-varied over glacial-interglacial cycles, which has been observed in paleoclimatic studies. Here, we review our current understanding and research results regarding biogeochemical records for the past global iron connections on different timescales. Paleo-records, such as terrestrial (loess) deposits, marine sediments and ice cores, suggest that average eolian deposition rates were approx. 2-20 times higher during glacial periods than during interglacial periods. During glacial times, enhanced dust supply to the ocean, particularly in the main HNLC areas of the open ocean (i.e., the Pacific subarctic, the equatorial Pacific, and the Southern Ocean), could have 'fertilized' the marine biota, enhanced the ocean productivity (1-2 times) and driven atmospheric CO_2 lower. Current models yield various results, predicting that glacial-interglacial changes in dust fluxes could produce changes in atmospheric $p\text{CO}_2$ ranging from 5-45 ppm as a contribution to the total glacial-interglacial change of 80-100 ppm. The positive correlations among Asian dust, ocean productivity and atmospheric CO_2 in the last 2,500 kyr, 1,000 kyr, 130 kyr, and 2 kyr indicate an important role of dust/iron in global biogeochemistry cycles in the past. A simple estimation confirms that a fourth of the glacial-interglacial CO_2 change induced from iron fertilization might be due to dust supply change in Asia and its associated productivity change in the Pacific Ocean.

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Detecting human impacts on the flora, fauna, and summer monsoon of Pleistocene Australia*Gifford Miller*

All of Australia's large mammalian vertebrates became extinct about 50 ka, shortly after human colonization 55 to 50 ka. Between 60 and 40 ka climate was similar to present and not changing rapidly. Consequently, attention has turned toward plausible human mechanisms for the extinction, with proponents for over-hunting, ecosystem change, and introduced disease. To differentiate between these options we rely on isotopic tracers of diet preserved in avian eggshells to track changes in ecosystems before and after human colonization. $\delta^{13}\text{C}$ preserved in eggshell calcite and in intracrystalline organic residues, monitor a bird's dietary intake in the weeks to months before egg laying. More than 500 dated eggshells from central Australia of the extant, large, flightless Australian emu (*Dromaius novaehollandiae*), an opportunistic dominantly herbivorous feeder, provide a continuous, 140 ka dietary $\delta^{13}\text{C}$ reconstruction; and additional >400 dated eggshells of the extinct, heavier, *Genyornis newtoni*, define its dietary intake from 140 ka until its extinction about 50 ka. Less continuous dietary records for both species were developed from two distant regions (>250 additional dated eggshells <130 ka old). *Dromaius* eggshell dietary $\delta^{13}\text{C}$ reveals an unprecedented reduction in food sources about 50 ka in both carbon reservoirs from all three regions, suggesting conversion from a tree/shrub savannah with occasionally rich grasslands to the modern desert scrub. *Genyornis* diet everywhere is more restricted than in co-existing *Dromaius*, implying a more specialized feeding strategy. The dietary shift observed in *Dromaius* eggshells ca. 50 ka is diagnostic of ecosystem collapse throughout the semi-arid zone shortly after humans colonized Australia, possibly a consequence of systematic burning by early humans. Those animals with feeding strategies that allowed them to adapt to a changed vegetation regime, such as *Dromaius*, survived; those with restricted dietary sources, such as *Genyornis*, became extinct. The change in vegetation would have also reduced biosphere-atmosphere interactions that promote penetration of monsoon moisture into the interior. Climate modeling suggests such a shift may reduce monsoon rain in the interior by as much as 50%.

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Monsoon and man in the Indian subcontinent

Ashok K. Singhvi

In respect of its human dimensions, the Indian monsoon is perhaps, the single most articulate weather system that determines the lives and the well being of a large fraction of the humanity. The monsoon system in the region depends on a variety of parameters ranging from the solar variability to ENSO events and to land oceans temperature contrasts, etc. Statistically valid correlation with up to 10 global parameters is seen. In an anticipated global warming scenario, two important aspects for the Indian context are, (i) the spatial variability and, (ii) the timing of rainfall events with in a season. Both of these have a direct bearing on the aspects of food security and human migrations. Considerable effort has been made in understanding the monsoon systematics, in parts through rigorous and empirical modeling efforts. Analysis of the rainfall trends from the instrumental records so far does not show significant deviation from the mean. Considerable effort has also been made to reconstruct paleo record using a varied set of proxies that range from tree rings to desert sands and using cores from tanks to deep ocean cores. Inferences from different sedimentary records of the Holocene have shown occasional discordance. For the more recent millennium the records are even more confusing. For example, the marine *G. bulloids* data have been used to suggest recent enhancement of the monsoon winds correlating to rising temperatures. Contrastingly, the instrumental data of the past century does not show any such trend. Rainfall reconstruction from man made tanks also support this inference. Tree ring data from the Himalaya show an overall cooling trend in the same period. Similarly the medieval warming and arid phase preceding it have been placed differently in different reconstructions. Archeological and historical records provide additional documentation of the monsoon. In this presentation, a synthesis of the current understanding of the paleo-records along with an evaluation of the proxies, their chronometry will be presented.

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Anthropogenic CO₂ signals recorded in stable isotopes of planktonic foraminifera from the northern Gulf of Aqaba, Jordan

Saber Al-Rousan, Jürgen Pätzold, Salim Al-Moghrabi, Gerold Wefer

The stable carbon isotopic composition of the planktonic foraminifera *Globigerinoides sacculifer* and *Globigerinoides ruber* (white) and sedimentary organic matter from the northern Gulf of Aqaba have been investigated to estimate changes in $\delta^{13}\text{C}$ DIC (dissolved inorganic carbon) in surface waters during the last 1000 years. The high sedimentation rates at the core sites (about 54 cm/ky) provide high temporal resolution (~10 years). Recent sediments at the top of the cores reflect conditions younger than 1950. The $\delta^{13}\text{C}$ records of the planktonic foraminifera from three multicores display similar trends, showing a uniform and consistent pattern before the 1750s, and a gradual decrease of approx. 0.63‰ over the last two centuries. This decrease seems to track the decrease of $\delta^{13}\text{C}$ DIC in surface waters, which is mainly caused by the increase of anthropogenic input of ^{13}C -depleted CO₂ into the atmosphere. Similarly, a trend toward lighter values of the carbon isotopic composition of sedimentary organic matter ($\delta^{13}\text{C}_{\text{org}}$) during the last 200 years supports the interpretation obtained from the planktonic foraminiferal $\delta^{13}\text{C}$. Furthermore, direct measurements of seawater show that $\delta^{13}\text{C}$ DIC in the northern Gulf of Aqaba has decreased by about 0.44‰ during the period 1979-2000. The average annual decrease is 0.021‰, which is similar to that observed globally. The $\delta^{13}\text{C}$ values of planktonic foraminifera combined with organic matter $\delta^{13}\text{C}$ from marine sediments are good indicators for reconstructing past changes in atmospheric CO₂ concentrations from the northern Gulf of Aqaba.

ANTHROPOGENIC CO₂, HUMAN EFFECTS, CLIMATE CHANGE, CARBON ISOTOPES, JORDAN

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Climate Change and the Qijia Collapse: 4,000 cal yr BP marks the end of an era in China's western Loess Plateau

Cheng-Bang An, Lingyu Tang, Loukas Barton, Fa-Hu Chen

New data suggest that dramatic environmental change in the Western Loess Plateau of China corresponds with substantial changes in human demography ca. 4,000 cal yr BP. These data demonstrate that a rapid climatic transition from wet to dry led to an ecologically devastated period between 4,000 and 3,600 cal yr BP. The sudden and dramatic reduction of archaeological sites during this period points to declining agricultural productivity associated with widespread aridification beginning at 4,000 cal yr. BP. In brief, the distribution of rain-fed agricultural cultures in the study area reached its maximum extent under stable environmental conditions between 7,800 and 4,000 cal yr BP but receded dramatically after 4,000 cal yr BP, coincident with a de-emphasis on agricultural subsistence.

CLIMATE CHANGE, AGRICULTURAL COLLAPSE, WESTERN LOESS PLATEAU, NEOLITHIC, CHALCOLITHIC

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A sub-decadal diatom inferred paleosalinity and $^{13}\text{C}_{\text{org}}$ record from the Aral Sea for the past 2000 years

Patrick Austin, Melanie Leng, Anson Mackay

The Aral Sea is presently undergoing extreme desiccation due to large scale irrigation strategies implemented in the 1960s. Recent archaeological evidence and the presence of former shorelines, indicate earlier desiccation events. As part of the INTAS funded CLIMAN project into Holocene climatic variability and the evolution of human settlement in the Aral Sea basin, fossil diatoms contained within an 11 m sediment core have been examined in order to reconstruct salinity and lake level changes over the last 2,000 years. The $\delta^{13}\text{C}$ record of organic carbon ($\delta^{13}\text{C}_{\text{org}}$) has also been obtained in order to better understand the physical environment in and around the lake. Paleosalinity has been derived using the EDDI Combined Salinity transfer function. Weighted averaging (WA) with inverse deshrinking was seen to perform best ($r^2=0.767$, RMSEP=0.469 \log_{10} $\mu\text{S/cm}$). Results indicate a water body fluctuating between fresh and oligosaline conditions punctuated by three phases of elevated

conductivity and low lake levels: (i) that of the present day since the 1960s; (ii) ca. 1000 yr BP, coinciding with the destruction of irrigation systems by the Mongols; (iii) the final regression which would appear to be concordant with an earlier destruction of irrigation facilities ca. 1600 yr BP. Diatom inferred conductivity and new archaeological findings from other CLIMAN partners suggest that the Medieval regression was at least as severe as the current episode. The C/N ratio of organic material throughout the core indicates that $\delta^{13}\text{C}_{\text{org}}$ provides a record of lake productivity, highest values corresponding with low lake levels.

ARAL SEA, LAKE LEVEL CHANGE, DIATOMS, TRANSFER FUNCTION, CARBON ISOTOPES

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Human adaptations to the Last Glacial Maximum: Technology and risk in China's Western Loess Plateau

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Archeological sites dating to the Last Glacial Maximum (LGM; 22-18 kyr BP) are rare in North China. The paucity of data from this interval is often explained by migration or population decline in the face of devastating environmental change. However, mounting evidence from the Western Loess Plateau suggests that the harsh climates and depleted landscapes of the LGM may have forced human populations to significantly modify their foraging strategies rather than vacate the region entirely. We suggest this adaptive shift is made possible by the long evolution of a fundamentally distinct tool technology native to the Western Loess Plateau. In glacially marginal environments, declines in local foraging efficiency necessitate smaller corporate groups and hyper-mobile hunting patterns to keep-pace with the expanding foraging patterns of increasingly migratory game. A necessary feature of this hyper-mobility is an expedient tool technology that mitigates against the uncertainty of tool-stone limitations in the Loess Plateau. Archaeological data suggest that LGM hunters employed composite armatures fitted with crude microliths generated by expedient bi-polar core-reduction on low-quality but highly abundant local quartz. This technology first emerges in the marginal highlands of the Western Loess Plateau prior to the LGM, proliferates during the cold-dry glacial, complements the post-LGM development of true microlithic technology, and persists through the transition to agriculture. Though few in comparison to

the preceding and succeeding intervals, the presence and character of archaeological sites in the Loess Plateau during the Last Glacial Maximum suggest in-situ modifications to human foraging behavior rather than wholesale population migration or extinction.

ADAPTATION, ARCHEOLOGY, MOBILITY, LAST GLACIAL MAXIMUM, CLIMATE CHANGE

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Late Pleistocene environmental changes in the Lower Narmada Basin, Western India

Subhash Bhandari

Late Pleistocene sediments are documented in the Lower Narmada Valley, western India. Two sedimentary packages deposited in alluvial fan and alluvial plain environments have been classified. The alluvial fan sediments were deposited around 90 ka and are overlain by overbank sediments associated with crevasse splay and backswamp deposits, large channel fills and epsilon cross bedded strata of alluvial plain environment. A thick reddish-to-brown paleosol correlatable to a pre-Last Glacial Maximum (LGM) phase of pedogenesis in the Gujarat alluvial plain is conspicuous. This is capped by thinly stratified sand and silt that date back to the arid phase of the LGM. The sedimentary characteristics in the lower Narmada Valley suggest a dominantly semi-arid to arid climate during the Late Pleistocene. During the Late Pleistocene, the river had a much bigger channel with discharge levels much higher than the present, thus revealing that the Narmada River operated in conditions much more humid than the present.

LATE QUATERNARY, FLUVIAL AGGRADATION, PALEOENVIRONMENT, LOWER NARMADA BASIN

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Evidence of wetter climate in Late Quaternary sequences of the coastal Saurashtra, Gujarat, Western India

Nilesh Bhatt, Uday Bhonde

The arid-semiarid region of western India have well preserved evidence of Quaternary climate change in the form of geomorphic and geologic variants. The Late Quaternary coastal marine and fluvial sediments of western and southwestern Saurashtra, facing the open Arabian Sea, have preserved a good record of climatic fluctuations that also has a profound control over the geomorphic set-up. The available geochronological dataset bracket the whole succession between ~200 ka and 3 ka which provides insight of the land-sea interactions, its environment and climate of the region. Three major depositional sequences have been identified in the study area hosting nine litho-units therein. The intra and inter sequence variations in structural, textural and compositional characteristics suggest moderate to sharp changes in the hydrological conditions of the area in the past. The study in general indicate three distinct periods during which the continental processes in the form of paleosol formation, fluvial aggradation and karstification of the coastal limestone dominated over the coastal one, characterized by the formation of successive beach ridges and associated sedimentary facies. These correspond to the periods immediate prior to the MOI stages 5, during stage 5 and then just after the stage 1. This Early Holocene wetness is recorded in the form of a surface of stability over ancient coastal dunes and seaward extension of the fluvial gravels. The geoarcheological studies carried out in the study area by the other workers also demonstrate regional climatic changes during Late Quaternary. The scenario during LGM is still a grey area in Saurashtra.

LATE QUATERNARY, CLIMATE CHANGE, WESTERN INDIA, SAURASHTRA

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Climatic influence on tropical grasslands in India

Asim Bhattacharyya, Bharati Bhattacharyya

The Indian grasslands have developed secondarily after destruction of forests. They are spread in all major bioclimatic regions of the country. All the tropical grasslands of India may be regarded as Savannah. Maximum growth rates are found at about 35°C, some 10°C warmer than the optimum for temperate grasses, and light intensity twice the optimum. The reason for this is that most tropical grasses have a different photosynthetic mechanism compared to temperate grasses. These biochemical reactions have given rise

to C4 and C3 plants. During the last few thousand years, the grasslands of India have undergone many changes. The West Indian desert (Thar) of Rajasthan today is characterized by a hot and dry summer followed by a cold winter. Historical evidence indicates that the area was under forests some 2000 years ago but was gradually destroyed by man for agricultural practices and became desert due to excessive dryness. In the North-Eastern region, Assam and its adjoining areas, where rainfall is more than 1,000 cm (world's highest), there has been development of dense evergreen forests of very rich biodiversity under a hot and humid climate. Over a long period of time, tribes and local peoples in this region have cleared forests and practiced "Jhum" (shifting) cultivation leading to the conversion of primary forests to secondary forests to grasslands. Indian Savannahs during the past four centuries have changed from mesic to xeric in nature and they have been divided into eight categories.

CLIMATE, TROPICAL, GRASSLANDS, HUMAN ACTIVITIES

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Post glacial climatic changes based on pollen from glacio-lacustrine sediments of Gangotri Glacier, Western Himalaya, India

Amalava Bhattacharyya, Parminder Singh Ranhotra

The Gangotri Glacier is one of the largest valley glaciers lying between 30°43'22"-30°55'49"N and 79°4'14"-79°16'34"E covering an area of about 143 km² in the northwest part of the Himalaya, India. This glacier forms the source of Ganga River at Goumukh (4,000 m asl). Here, temporal climatic changes during the last postglacial period are discussed based on palynological studies of the sub-surface sediments close to the snout of Gangotri Glacier. This study suggests that climate around 9,000 yr BP was warm-moist, which changed to comparatively drier climatic conditions around 8,300-7,600 yr BP. Around 7,000-6,000 yr BP, the climate reverted to warm-moist. Subsequently, after 6,000 yr BP to around 3,000 yr BP climate again became drier. Around 2,000 yr BP, climatic conditions became cooler and moister, and further amelioration took place around 1,700 yr BP. Around 1,000 - 850 yr BP, the sharp increase of steppe elements reflect a trend towards drier climatic conditions. During recent times, climate again reverted to warmer conditions, reflected by the increase of Betula, Pine and other trees. The pattern of climatic changes around the Gangotri region shows similar trends to several other regions, especially the northwest and northeast part of the Tibetan plateau and Sahara Arabian Zone.

PALEOCLIMATE, POST GLACIAL, WESTERN HIMALAYA, POLLEN, INDIA

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Natural evolution of landscapes and human influence in the Altai Mountains, south of Western Siberia

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In the middle of the Eurasian continent, where wet Atlantic air masses meet cold dry air of the Siberian Anticyclone, in the area of the Altai Mountains (50°30'-50°23'N, 87°40'-89°37'E), sediments from five high mountain lakes were investigated by pollen and radiocarbon analyses. Pollen sequences from each of the sites cover about 12,000-13,000 years and reveal some global changes in landscape, such as alteration of steppe and forest stages. Numerous AMS radiocarbon dates settled exact boundaries of these stages. Charcoal and algae spores were counted as anthropogenic markers. The most significant change in landscape, took place 9,000-8,000 years ago, when open steppe was replaced by forest-steppe and forest landscapes. Dark coniferous forests spread in Altai in middle Holocene. From 9,000-7,000 years ago taiga occupied the greatest areas during investigated time. Along "forest bridges" a tribes of hunters penetrated to Mongolia and left their traces in Mongolian Neolithic culture. After 5,000 years ago the decrease of summer insolation (started after maximum at 9,000 years) caused decrease of moisture in central Eurasia and role of forests begin to decline. Human cultures of bronze age started to spread in this area almost simultaneously with climatically induced decrease of forests. The beginning of deforestation was marked by sharp maximum of charcoal in lake sediments. Role of steppe elements in landscape especially increased 2,000-1,500 years ago. Anthropogenic markers, such as charcoal and algae together with pollen data give clear signal about development of kettle breeding cultures in central Asian areas.

POLLEN, CLIMATE, RADIOCARBON, VEGETATION, HUMAN

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Recent warming over western Himalaya, India observed from tree-ring estimates since AD 1603

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High-resolution proxies derived from high-altitude near-glacier tree-ring chronologies of *Cedrus deodara* show an unprecedented surge in growth since the 1930s. The chronologies do not show any other such significant episode of higher growth prior to this time. Such significant higher growth in recent years was not observed in middle- to low-altitude chronologies of Himalaya, which are away from the direct influence of the glacier activities. The tree growth-climate relationship based on correlation and response-function analysis indicates a significant positive relationship with maximum temperature during winter. The warm weather in winter is believed to result in thawing of tissues, promoting the subsequent growth, which gives a positive relationship between winter temperature and tree growth. Tree-ring reconstruction of winter (November-February) maximum temperature indicates unprecedented warming during recent decades since AD 1603. This may be explained as an effect of winter warmth. Particularly after 1940, a significant increasing trend in surface temperature is observed with more positive anomalies. During the last few decades, many Himalayan glaciers have been shrinking at a significant rate. This matches with the significant increase in winter temperature over Western Himalaya since 1940 and the abrupt increasing trend in annual growth pattern of the high-altitude trees. A similar anomalous increase in temperature is also noticed in Northern Hemispheric temperature derived from a proxy data network for the past millennium. Century-long instrumental records of temperature over the region also indicate more increasing trend during the recent four decades, similar to temperature changes observed in many other parts of the globe. The reconstruction shows some cool epochs associated with intermittent warm episodes, with the 1990s as the warmest decade.

WESTERN HIMALAYA, WARMING, TREE-RING, RECONSTRUCTION, WINTER TEMPERATURE

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Late Pleistocene and early Holocene hunter-gatherer occupation of the high-elevation northern Tibetan Plateau

P. Jeffrey Brantingham, Xing Gao, Haizhou Ma, John Olsen, David E. Rhode, David B. Madsen

Geological and archeological surveys of the Kunlun Pass and surrounding high plateau areas have identified a unique archaeological signature for hunter-gatherer occupation of the region. Blade and microblade lithic technologies using a diverse range of stone raw materials, including obsidian, are found in spring, alluvial and glacial terrace contexts ranging in elevation from 4,100 to 5,000 m asl. While most of these sites remain undated, one stratified archeological site at Xidatan is directly associated with previously published cosmogenic surface ages on glacial outwash terraces. Xidatan 2 provides limiting ages of between 6276 ± 262 and 8216 ± 346 BP (calendric) for the occupation of the site. Evidence supporting short and long chronologies for human occupation of the high elevation Tibetan Plateau is discussed.

TIBET, PALEOLITHIC, COSMOGENIC DATING, LATE PLEISTOCENE, ARCHEOLOGY

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Holocene paleoclimate of north-central India from lake sediments

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A 1.2 m sediment profile extracted from a paleolake in Himachal Pradesh, India provides a continuous record of sediment organic matter and hence the history of the lake over the last 9,800 years. The C/N ratios until 4000 cal yr BP indicate that the organic matter was predominantly from aquatic production. During this time, the lake level started to fall due to a decrease in summer monsoon rainfall. This decrease in lake level has been manifested in the carbon isotopic ratio of the organic matter that showed a +2‰ change. This is the time when $\delta^{13}\text{C}$ of organic matter attained a value of -23‰, being the maximum for the available record. From this time onward, terrestrial organic matter started penetrating the lake system. Since this time, the lake underwent a few dry and humid phases until

about 1000 cal yr BP. Then the lake completely dried up around 800 cal yr BP, due to the emergence of a dry phase.

CARBON ISOTOPE, LAKE SEDIMENT, HOLOCENE, PALEOCLIMATE

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Expected effects of temperature rise on glacier extent and long-term water availability in the Nepal Himalayas

Narayan Prasad Chaulagain, Olav Hohmeyer, Ingrid Nestle

Temperature records from Kathmandu, Nepal, show that the 1990s was the warmest decade since 1970. Seven out of ten years in the 1990s were the warmest years in the record. Increasing temperature is causing accelerated retreat of the glaciers in Nepal Himalayas. Detailed mass balance analyses of the glaciers in Langtang valley in central Nepal based on the observed hydrological, meteorological and glaciological data reveal that the glaciers were melting by nearly 1100 mm annually in the 1990s. Applying the output of these analyses, all glaciers of Nepal were examined. The results show that about 73% of the present glacier area, about 87% of the present ice reserve and about 98% of the number of glaciers in Nepal Himalayas will disappear by 2100, if their current melting rate continues. This will cause a reduction in annual glacier-melt water in Nepal from 10.5 km^3 in 2001 to 2.9 km^3 in 2100. After widespread shrinkage of the glaciers in Nepal, many of the present glacier-fed river systems will be converted into rain-fed ones. Generally, the rain-fed rivers of Nepal have higher seasonal flow-imbalances than the glacier-fed ones. Disappearances of glaciers not only reduce the total water availability required for socio-economic activities of millions of people living downstream, but also result in more pronounced seasonal imbalances of flows and consequently more floods during summer (June-September) and more droughts during other seasons. This might cause seasonal water stresses despite too much of water in the summer.

GLACIER MASS BALANCE, GLACIER RETREAT, CLIMATE CHANGE, FLOODS, DROUGHTS

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Planktonic foraminifera and their paleoceanographic implication for the Indonesian Archipelago during the last 18 ka

Xiaoyun Chen

The Indonesian Archipelago is situated to the east of the Indian Ocean, at the boundary between the North Indian Ocean and the West Pacific. It belongs to the Western Pacific Warm Pool and is strongly affected by monsoon wind action. Results of $\delta^{18}\text{O}$, $\delta^{13}\text{C}$ and planktonic foraminiferal assemblages obtained from the core SHI-9011 from the Indonesian Archipelago indicate that sea surface temperatures (SST) were high during the interglacial, the relative abundance of warm water species was increased, and paleoproductivity was high. On the contrary, SSTs were low, the relative abundance of warm species was decreased, and paleoproductivity was low during the Last Glacial Maximum. SST and paleoproductivity estimates from the top 30 cm of the core are low. In analogy to other areas influenced by the East Asian monsoon, the Indonesian Archipelago may have experienced a strengthened southeast monsoon at about 8 ka BP.

INDONESIAN ARCHIPELAGO, LAST 18 KA, $\delta^{18}\text{O}$, PLANKTONIC FORAMINIFERAL ASSEMBLAGES, SST

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Late Quaternary East Asian monsoon variability in the South China Sea: Evidence from planktonic foraminiferal faunal and hydrographic gradient records

Min-Te Chen, Pai-Sen Yu

The hydrographic conditions of the surface of the South China Sea (SCS) are influenced strongly by fluctuations of the East Asian Monsoon (EAM). Long-term fluctuations of the EAM have been previously investigated through analysis of several proxy records obtained from SCS sediment cores. However, in this marginal sea, interpretation of these records is complicated by ice volume/sea level effects. For this purpose, we generated high-resolution records of planktonic foraminifer faunal assemblages and estimates of SST of the last ~135 kyr from two cores, taken off the Vietnam margin (MD012394) in the western SCS and near Palawan Island (MD972142) in the southeastern SCS. We established a Planktonic Foraminifera Hydrographic Index (PFHI) based on the abundance ratios of warm/thermocline and cold/mixing species assemblages and sea surface temperature (SST) estimates from a Modern Analogue Technique (MAT). The east-west gradients of the PFHI and SST (DPFHI and DSST) between cores MD012394 and MD972142 with time show a dominance of 23-kyr precession cycles. In the precession cycles, the DPFHI and DSST increased at the December 21 perihelion, which is associated with

seasons of minimum northern hemisphere winter and maximum southern hemisphere summer insolation. Cross-spectral analysis between the DPFHI and DSST with the precession cycles indicate coherent and in-phase relationships. Considering that the December 21 perihelion of the cycle of precession accorded with the time of maximum summer insolation in the southern hemisphere, we suggest that the SCS variability of hydrographic gradients for the last 135 kyr has been dominated by winter monsoon dynamics in response to geographic forcing controlled by the strength of the Australian summer monsoon.

MONSOON, SOUTH CHINA SEA, GLACIAL CYCLES, LATE QUATERNARY, SST

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Dinocyst lamination—a natural clock of freshwater “red tide” recorded in lacustrine sediment

Guoqiang Chu

For the last few decades, dinoflagellate blooms have been widely observed in marine and estuarine environments, while sparsely found in a few freshwater lakes. Dinoflagellate bloom has been suggested as an endogenous annual clock, however, this episodic phenomena is still poorly understood. Here, we report a special type of varve, which possibly consists of dinoflagellate cysts in recent lacustrine sediments. We only sampled live cells in May, July and September. Live cells (*Peridinium cinctum*) were found in the samples from September. However, dinocysts in the sediments are not produced by this species. Preliminary sediment trap results show one distinct peak of dinocysts in November, and this may be linked to autumn overturn in the lake. The highest ^{137}Cs detected at a depth of 5 cm is assumed to correlate to the 1963 maximum of emission due to nuclear bomb testing. Totally, 40 varves were counted in the upper 5 cm of the core, which is in good agreement with the ^{137}Cs chronology. ^{210}Pb and ^{14}C data (3490 ± 90 yr BP at a depth of 186 cm, 4780 ± 80 yr BP at 286 cm) also supports annual lamination. The dinocyst laminations provide long-term datasets to understand the changing environmental factors that permit certain species to bloom at yearly intervals of time. In the future, emphasis will be given to the annual occurrence of the cyst lamination.

DINOCYST, LAMINATION, FRESHWATER

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Tree-ring reconstructions of Asian monsoon climate Dynamics

Edward Cook, Gordon Jacoby, Rosanne D'Arrigo, Brendan Buckley, William Wright

The Asian monsoon climate system plays a significant role in large-scale climate variability over much of the globe. Due to its considerable importance to global climate and implications for the world's population, there is an urgent need for greater understanding of this system, with the ultimate goal being improved prediction on annual to decadal and longer timescales. The Lamont-Doherty Earth Observatory's Tree-Ring Laboratory has begun a five-year research project, funded by the U.S. National Science Foundation, that will apply the science of dendrochronology to investigate several as yet unanswered key questions regarding the long-term relationships between the Asian monsoon and three large-scale coupled processes that drive much of its variability: 1) Asian land surface air temperatures, 2) Sea surface temperature (SST) anomalies in the Indian Ocean, and 3) Tropical Pacific SST anomalies associated with the El Niño-Southern Oscillation (ENSO). Other climate teleconnections will also be studied as they relate to Asian monsoon variability. To these ends, our Asian monsoon project is directed towards answering one overriding research question: How have these large-scale coupled processes, responsible for driving much of the observed Asian monsoon climate dynamics, varied and interacted on inter-annual to centennial timescales? This over-arching question will be investigated through within- and between-region analyses of centuries-long, space-time climate reconstructions developed from a 'Monsoon Asia' tree-ring data network now under development. Progress in the development of this tree-ring network and its use in reconstructing Asian monsoon climate variability will be described.

MONSOON, DENDROCHRONOLOGY, CLIMATE, RECONSTRUCTION

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Environmental crisis in the Erhai catchment, Yunnan Province, China 1000 CE to present

Darren Crook, Gez Foster, Shen Ji, Mark Elvin

This poster extols the virtues of adopting an internationally driven integrated inter-disciplinary approach to evaluating the impacts of global change on vulnerable human communities. It presents some preliminary results of a Leverhulme-funded research program looking at the sensitivity of the Erhai catchment in Yunnan Province, China to climatic and human impacts over the last 1000 years. A range of sedimentary sources and analytical techniques and methods are used and set against historical records of temperature and precipitation and archaeological and documentary archives to reconstruct long-term hydrological trends in the Erhai catchment. The advantages of employing such a methodology are illustrated through the case study of the Baihan Dry Gorge. Its history provides a broader signal for long-term environmental crisis throughout the wider Erhai catchment starting in the Ming Dynasty that still has ramifications for the decision making of environmental managers and policy makers today.

YUNNAN, ERHAI, FLOODING, DRY DYKE, MIJU

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Palynological assemblages and their environmental implication in core DGKS-9602 from the East China Sea

Yun Deng, Zhuo Zheng, Serge Berne

The East China Sea is one of the largest continental shelves in the Pacific Ocean. A piston core (DGKS-9602) located at 28.12°N, 127.37°E was collected within the framework of the French-Chinese cooperation in marine science and technology. The core with a water depth of 988 m and a length of 931 cm is composed mainly of fine-grained deltaic sediments related greatly with sedimentation of the Yangtze River. A total of 89 samples were collected for multidisciplinary studies, among which the pollen analysis were carried out to investigate the change of vegetation and climate, and to evaluate the evolution of the East Asian monsoon since the Late Pleistocene. The Chronological model was based on the AMS ^{14}C and $\delta^{18}\text{O}$ stage comparison. The age of the core includes the last glacial-interglacial cycle (OIS 4-1) that is positively compared with $\delta^{18}\text{O}$ curves of SPECMAP. The pollen data of DGKS-9602 core clearly shows the terrestrial floristic changes.

An analogue method based on the East Asian Pollen Database was used to quantitatively reconstruct the paleoclimate of the region. Result shows that at OIS 3 and 4 of the Last Glacial period, the estimated mean annual temperature was averagely 4-6°C lower and the annual precipitation about 250 mm lower than today. Besides, the Last Glacial Maximum (OIS 2) was characterized by much greater climatic deterioration with the mean annual temperature ~10°C and the annual precipitation respectively ~700 mm lower than those of present-day.

EAST CHINA SEA, PALYNOLOGICAL ASSEMBLAGES, PALEOCLIMATE, EAST ASIAN MONSOON

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Understanding desertification: Human agency and Holocene climate change in Jilantai Basin of Western Inner Mongolia, China

Robert Elston, FaHu Chen, David B. Madsen, Changbang An, Dongju Zhang

Although it is generally accepted in China that late Holocene desertification is associated with farming rather than pastoralism, certain forms of pastoralism are very destructive in semi-stable sandy deserts. Grazing camels and goats can together denude semi-stable sandy desert plant communities in a matter of weeks, destabilizing dunes, and sometimes creating irreversible gobi; such impacts are intensified in cold dry intervals. Even before the Bronze Age advent of camel nomadism, pastoralists may have been instrumental in late Holocene degradation of fragile sandy desert environments if herders were restricted to smaller territories with relatively low carrying capacity. If herds grew large during warm moist intervals, attempts to maintain herd size in cold dry intervals could have resulted in vegetation degradation and release of dunes from basin margins. In the Tengger Desert of western Inner Mongolia, paleoenvironmental evidence suggests that Holocene dune encroachment into lake basins is correlated with cold dry climate. If pastoralism accelerated this process, then periods of desertification should begin to accelerate earlier in cold dry intervals of the late Holocene than in the early Holocene, especially after the appearance of camel pastoralism. We are testing this hypothesis with ¹⁴C and OSL-dated archaeological, sedimentological and palynological records gathered from Jilantai Basin in the NE Tengger and compared to climate cycles dated in ice cores.

DESERTIFICATION, HOLOCENE, CLIMATE, PREHISTORY, PASTORALISM

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Processes and mechanisms of climate variability over the last 40 years in the Salt Lake Basin of Iran *

Tahereh Ensafi Moghaddam

In discussing the climate of arid regions, where warming energy supply at the earth's surface is excessive and rainfall is deficient, one needs some comparative measure of aridity. The purpose of constructing an index or a model may be manifold. One such purpose is the assessment of the proneness of an area towards aridity or desertification, which would then allow implementing precautions. Hence we need an index of aridity. In this investigation, the Aridity Climate Index (ACI) was established. It was generated by use of statistics and drawing methods including collection, communication, correlation, regression line, data generation, and component analyses of meteorological information, using about 35 stations that have 40 years service from 1957 to 1996. The ACI ratio $Z = (X_i - X)/S$ is based on principal components of the set of climatological data, with Z being the standard score, X the mean and X_i the variable of every class, and S their deviation. The present study has assessed the Salt Lake Basin of Iran through various statistical analyses and application of this index. This investigation indicates the dominant relation between climate and desertification/aridity. The index suggests climatic effects on desertification and is a suitable criteria for determining aridity and its propagation. Here, I explore the climatic stresses that underline the precipitation and temperature. Based on this index, and its classification and 45 output maps, desertification limits have been determined from year to year by GIS and ILWIS software application. Also, the change of aridity zones of dry-lands in the Salt Lake Basin in every year of one long term, has been accounted by ILWIS software. The conclusion of this investigation indicates that in climatic respect, the Salt Lake Basin of Iran is leading towards climatic desertification.

CLIMATIC FLUCTUATIONS, DROUGHT, IRAN, CLIMATIC VARIABILITY, SALT LAKE BASIN

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Sedimentary phosphorus speciation and diagenesis in the IMAGES core MD972146, northern South China Sea

Tien-Hsi Fang

This study presents results of different forms of sedimentary phosphorus, based on the sequential extraction method of Ruttenberg (1992), carbonate, organic carbon, opal, and reduced and non-detrital forms of Fe and Mn concentrations from a high-resolution record IMAGES MD972146 of the northern South China Sea (SCS). The age model indicates that this record has a very high sedimentation rate of 40~50 cm/kyr and covers the past 100,000 yrs. The concentration of total phosphorus (TP) in this core ranged from 12.6 $\mu\text{mol/g}$ to 17.4 $\mu\text{mol/g}$. Total inorganic P (TIP) was the dominant species and accounted for nearly 90% of TP pool. The reactive ferric Fe-bound and detrital forms of P were the equally important fraction of TIP pool. The concentration profiles of TP and carbonate significantly decreased with increasing depth in the depths 630-900 cm interval, which corresponded to the age of 18-25 kyr. This result may imply that the terrestrial input to the SCS during the glacial period of stage 2 was relatively lower than that of the other stages. The concentration profiles of organic P gradually decreased with increasing depth. The concentrations of reduced and non-detrital forms of Mn in this core were in the range of 0.02-9.4 $\mu\text{mol/g}$ and 2.6-19.1 $\mu\text{mol/g}$, respectively. The concentration profiles of reduced and non-detrital forms of Mn nearly matched in the whole depth and showed decrease with increasing depth until depth at 630 cm, afterwards, increased with increasing depth until depth at 900 cm. Then, the concentration significantly decreased with increasing depth until depth at 1,500 cm. Behind this depth, the concentrations of reduced and non-detrital forms of Mn were almost exhausted. Similar pattern of both forms of Fe was also observed but the concentration was not exhausted. These results indicate that the diagenetic process was active and the diagenetic sequence came to iron oxides.

PHOSPHORUS, MD972146, DIAGENESIS, SOUTH CHINA SEA

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Aerosol transportation and accumulation in Central Asia

Alexander Finaev

Deflation processes in Central Asia deserts are the sources of aerosol incoming to atmosphere. Due to atmospheric circulation aerosol is transferred and falls out in mountain regions of Pamir-Alay and Tien Shan. Due to atmospheric circulation laws, air masses move

from west and southwest to east and northeast over Tajik territory. Transport direction depends on type of cyclonic activity in particular season. Mountain ranges of Pamir and Pamir-Alay interfere with the further promotion of air. Stagnation and change of vertical speed components result in aerosol fallout, which after is collected on the surface. Field researches have shown that grain size distribution is done according to Junge law. Particle number density from 2.5 μm up to 10 μm in clear atmosphere reached 2 cm^{-3} , and during dusty storms ("Afghan") it increased up to 10-12 cm^{-3} . The analysis of climatic and orographical conditions was essential for creation of 3-D calculation model of aerosol transportation and sedimentation in the area of loess formation. The model takes into account the function of particle distribution in sizes ($N(r)$), height of the surface above sea level (H_0) with the scale of 10×10 km, the convective layer top border (H_k), duration of haze. Model calculations results show, that the thickest accumulation layer is formed in southern areas and reaches 0.5-0.6 mm/year. Average thickness of dust accumulation in Tajikistan makes 0.2 mm/year. This accumulation layer thickness agrees with the data on loess sections of early Holocene.

AEROSOL, CLIMATE, LOESS, ACCUMULATION, TRANSPORT

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Changes in C3/C4 vegetation as indicated by stable organic carbons isotopes in loess sequences in Northern Mongolia and Central Chinese Loess Plateau

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Stable organic carbon isotope ratios ($\delta^{13}\text{C}$) are routinely used to characterize the C3/C4 plant balance. High accumulation rates and very weak pedogenesis of loess deposits favors the organic matter $\delta^{13}\text{C}$ ($\delta^{13}\text{C}_{\text{OM}}$) preservation and the studies of paleoenvironmental and paleovegetation changes. We compare high-resolution (300 years) $\delta^{13}\text{C}$ analysis of two loess sequences: The Dorolj sequence (49°26'N, 103°E, 890 m) sampled in the northern part of Mongolia covers the last 30 ka; The second, located in the central Chinese loess plateau near Luochuan (36°N 109°30'E, 850 m), covers the last climatic cycle. Both sequences show similar $\delta^{13}\text{C}_{\text{OM}}$ amplitude range, however they are negatively correlated. In Mongolia, the low S_0 soil $\delta^{13}\text{C}_{\text{OM}}$ indicate a predominance of C3 plants while a major contribution of C4 plants (high $\delta^{13}\text{C}_{\text{OM}}$) is evidenced during the last glacial time (L1 Loess). Conversely, at Luochuan, warm periods (So and S1 soils) indicate a large contribution

of C4 plant and cold periods (L1,L2 loess) show a larger contribution of C3 plants. We suggest that the carbon isotopic variations indicate seasonality changes of the precipitation regime inducing the occurrence of C4 plants resulting from longer dry season rather than drastic changes in monsoon precipitation rates during Glacial/Interglacial transitions only.

CARBON ISOTOPES, LOESS, C3/C4 PLANTS, CHINA, MONGOLIA

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Primary study of Holocene climatic instability in the middle part of Gansu Province, China

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Three Holocene loess-paleosol profiles, respectively located in Tongwei, Gangu and Beidao County, Gansu Province, were studied by field investigation and laboratory analysis of grain-size and magnetic susceptibility. These records indicate that Holocene climate in our studied area was unstable. During the early Holocene, a climatic deterioration event (ca. 9900 yr BP) had broken the amelioration process. Although the weather was warm and moist as a whole in the middle Holocene (8500-3100 yr BP), it was not constant and continuous especially during 6000-5000 yr BP represented by a layer of loess (L_x) lying between the two layers of paleosol S_{01} and S_{02} . 7300-6900 yr BP and 4000-3600 yr BP were two other aridity phases in the next place. Since 3100 yr BP, paleo-monsoon reformed on a large scale again and the climate entered into a dry and cold period, therefore, eolian loess accumulation intensified and the topsoil deteriorated. At the same time, these climatic indexes also show that the southeastern part was obviously warmer and wetter than the northwestern part in Gansu Province since about 11,500 yr BP. These results may play an important role in understanding the regional response to global

change in the semi-humid to semi-arid zone.

HOLOCENE, CLIMATIC INSTABILITY, MAGNETIC SUSCEPTIBILITY, GRAIN-SIZE, GANSU PROVINCE

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Vegetational record for 12,000 years from Naradu Glacier Lake, Himachal Pradesh, India: Evidence of the influence of monsoon in the high Himalayas

Rajinder Kumar Ganjoo

The Naradu Glacier Basin, in the High Himalaya of Himachal Pradesh (India), is situated above the altitude of 4,300 m asl. Preserved in the glacier lake, situated at 4,100 m asl, are almost 2.5 m thick silty clay and fine sand sediments of lacustrine origin. The lake sediments have been dated by ^{14}C method to obtain the time bracket for the deposits, which ranges between 12,000 cal yr BP to almost 10,500 cal yr BP, and thus preserving the vegetational record of roughly the last 1,500 years. The early Holocene pollen record suggests the initial lowering of the snout, followed by the advancement of the treeline, suggesting the amelioration of climate in the region. The taxa reported reflect the direct influence of the monsoon in the High Himalayas, at least during early the Holocene.

NARADU GLACIER, LAKE, POLLEN, EARLY HOLOCENE, INDIA

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Holocene mud deposits on coasts and shelves: Processes and environmental records

Shu Gao

Holocene mud deposits are formed on wide continental shelves with abundant sediment supply. For instance, in the East China, Yellow and Bohai Seas, mud deposits are distributed in tidal flats, on river deltas, over sub-aqueous deltas that are associated with large rivers, and on open shelf areas, with a thickness of 102 m. Compared with coarse-grained deposits, the shelf muds are accumulated in relatively stable environments. Hence, they represent a suitable geological record for studies on climate and environmental changes. Investigations into the modern sediment dynamic processes indicate that these deposits have potential of providing high-resolution information of past changes. Further, a "forward modeling" approach, in

conjunction with “inverse” approaches, helps with an improved understanding of: (1) spatial distribution patterns of the mud deposits; (2) the sources and transport pathways of the fine-grained sediment; (3) the history of the formation of sedimentary facies; and (4) interrelationship between the sedimentary record and climate conditions when the deposit was formed. Understanding the modern sedimentary processes is also critical to the studies of the shallow marine geochemistry and biogeochemistry, material cycling, ecosystem dynamics and environmental protection. In the future, the freshwater and sediment discharges from the land are expected to differ from the conditions encountered in the Holocene, in response to natural forcing and human activities. Thus, the study of the modern sedimentary processes is not only necessary for the interpretation of the Holocene records, but it is also important for predicting the future environmental changes.

MUD DEPOSIT, HIGH-RESOLUTION RECORD, SEDIMENTARY PROCESSES, ENVIRONMENTAL CHANGES, CHINA SEAS

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22 Myr-climate history recorded in eolian deposits in China

Zhengtang Guo, Qingzhen Hao, Jianjing Wei, Shuzhen Peng, Zhisheng An, Dongsheng Liu

The 22-Myr eolian deposits in China documented climate changes at different time-scales. The onset of loess-soil formation by 22 Myr indicates the existence of sizeable inland deserts in Asia as dust sources, an energetic winter monsoon as dust carrier and a summer monsoon as a supply of moisture. From 22 to 6 Myr, evolution of the aridity was not strongly correlative with the global cooling trends. However, the drying history since 6 Myr matches the ongoing high-latitude cooling and the consequent expansion of Arctic ice. Some events also coincide with proposed uplift of portions of the Tibetan Plateau. The average duration of each Miocene loess/soil pair is well within the bandwidth of orbital-scale variations. Pliocene changes were dominated by ~41 ka cycles, consistent with the marine records. Most of the Quaternary proxies yield frequency patterns essentially similar to that of the marine record. However, original eolian grain-size is characterized by a near-lack of the ~100-ka cycle and a predominance of ~40-ka and ~23-ka cycles, indicating a strong control of insolation changes. Chemical weathering of loess also shows millennial changes of the summer monsoon correlative with those in the circum-North Atlantic region.

LOESS-SOIL SEQUENCE, MIOCENE, CENOZOIC, CLIMATE, ASIAN DESERT

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Global change studies in India—A science manager's perspective

K.R. Gupta

India is ideally suited to understanding global climatic changes, a topic that is widely discussed in the context of their impact on human environment. With its huge mountain chain, major river systems, coastal basins and lagoons and above all its unique monsoonal system, India offers the right settings for paleoclimatic reconstructions. The ability to read and interpret terrestrial proxy records is key to extracting information on past climates. The application of suitable methods to model various processes is the next step. Here, I present the major initiatives in paleoclimatic research in India, and future directions. The Indian Government is facilitating research on a wide variety of themes in this area. Centers for stable isotope studies, geochemistry, dedicated programs on glaciology, etc. are some of its active research initiatives. The focus so far has been to generate basic data for geological correlation and paleoclimatology and to develop appropriate models; these research programs are being carried out by organizations and various universities/research institutes. Improvements in the sensitivity of measurement of cosmic ray-produced isotopes in environmental samples have broadened the scope of their applications to characterize and quantify a wide variety of Earth System processes. Comparative studies of continental and marine records provide information on regional factors contributing to climatic changes. We have developed methods to retrieve such data and model them but we still need to develop techniques for sampling some of the archives, particularly long glacier cores and lake sediments. Reconstruction of rainfall intensity, at least for the last 100 ka, is important for developing climate models. It is imperative to have effective international collaboration in the above-mentioned areas.

GLOBAL CHANGE, PALEOCLIMATE, PROXY RECORDS, INTERNATIONAL COLLABORATION

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Frost rings in spruce wood on the upper tree-line on the South Ural Mountains

Marina Gurskaya

Frost rings in a stem of trees form under influence of such extreme climatic phenomena, as frosts during a growth season. On the upper treeline in the South Ural Mountains frost rings were researched to reveal frost frequency, time of their appearance during a season of growth, intensity and distributions of frosts on three different high-altitude levels with different density of trees. Then obtained data compare with age structure of this upper treeline forests during last 100 years and reveal connection between frosts and age structure of stands. The upper treeline on South Urals consists of spruce (*Picea obovata* Ledeb.). Cores from 1,000 trees on 0.2 m stem height were collected on three high-altitude levels. The first is at 1370 m asl (the zone of separate trees), the second is at 1300 m (the forest-tundra) and the third at 1250 m (the forest zone). Three degrees of frost ring expressiveness were revealed: weak degree of frost rings, middle degree and heavy one. The heavy degree of damages prevails on the second level, the average is on the third, and the weak is on the first. Frequency of frost rings increases down to slope. It can be connected with age structure of forest and prevalence of young generation of trees on the second and third levels. Frosts are observed more often at the beginning of growth season in June, than in July in the end of season of growth. However, frequency of the strong frosts is a constant on all three levels and it is 0.2.

SPRUCE, FROST, TREE RINGS, SOUTH URALS

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Responses of mangrove to Holocene environmental change, Western Ganga-Brahmaputra Delta, India

Arghya Hait, Hermann Behling

Palynological data from a 50-m-long core fitted in a ¹⁴C framework have been utilized to study environmental change and mangrove dynamics at a coastal site (Pakhiralaya) on the Sundarban biosphere reserve, Western Ganga-Brahmaputra Delta, India. This biosphere reserve is a unique ecosystem that harbors rich and diverse mangrove flora, fauna and microorganisms. A large number of people are directly dependant on this forest ecosystem for their livelihood. Data indicates the presence of a mangrove forest in the area for the last 8800 yr BP. The development of the forest was not continuous throughout this time. Climatic fluctuation is not viewed as a direct factor, since the warm and wet regime has remained fairly constant in this region since the early Holocene, rather the continuity was

interrupted by fluctuating sea levels. In brief, Holocene environmental and mangrove dynamics at Pakhiralaya are as follows: 1. 8800-8000 yr BP: Brackish water estuarine - development of mangrove in the area. 2. 8000-7500 yr BP: Transgression of the sea - development of mangrove halted. 3. 7500-7000 yr BP: Recolonization of mangrove as a result of stabilization of the sea. 4. 7000-4000 yr BP: No mangrove - fluctuation of the sea. 5. 4000 yr BP-present day: Regression of the sea - progradation of the delta and establishment of the present day supratidal terrestrial condition. This unique ecosystem is currently under stress due to the decrease in supply of fresh water and overexploitation. Protection of this mangrove ecosystem is essential and urgent.

MANGROVE DYNAMICS, HOLOCENE, PALYNOLOGY, GANGA-BRAHMAPUTRA DELTA, INDIA

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Extreme temperature events in summer in northwest Siberia since 100 BC inferred from tree rings

Rashit Hantemirov, Ludmila Gorlanova

At high latitudes cold summers as well as frosts and abrupt temperature declines during the growing season have a strong effect on the state, functioning, and stability of ecosystems. The analysis of anomalous structures in tree rings provides a promising method for reconstructing such events in times before the advent of instrumental meteorological observations. Missing and narrow tree rings, and two types of micro-anatomical trace in the wood (light and frost rings) of living and dead (subfossil) individuals of Siberian larch (*Larix sibirica* Ledeb.) growing at the polar tree line in northwest Siberia (Yamal Peninsula) have been used for the reconstruction of extreme temperature events over the past 2100 years. According the reconstruction the most severe temperature events were in 42 BC and AD 143, 536, 627, 640, 738, 801, 816, 1259, 1342, 1453, 1466, 1548, 1560, 1601, 1783, 1816, 1818 and 1820. Comparison of our data with data from other regions of the world shows that there is agreement in the timing of some extreme temperature events between several regions. Most probably, these extremes have been caused by climatically effective explosive volcanic eruptions.

EXTREME TEMPERATURE EVENTS, TREE RINGS, LARIX SIBIRICA, NORTHWEST SIBERIA, VOLCANOES

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Magnetostratigraphy of a late Miocene-Pliocene loess-soil sequence in the western Loess Plateau in China

Qingzhen Hao, Zhengtang Guo, Shuzhen Peng, Yansong Qiao

Eolian deposits of Pliocene age have never been reported from the western Loess Plateau in China. Here, a 73.7 m eolian sequence is dated using magnetostratigraphic method and micromammalian fossils. The polarity zonation correlates with the geomagnetic polarity timescale (GPTS), from Chron 3Br.1r to Chron 2An.3n, indicating an age from 7.10 to 3.52 Ma BP. The sequence is characterized by clear expression of eighty-four pairs of loess and soil layers while individual soils are basically indefinable for the eolian deposits of the same age in the eastern Loess Plateau, suggesting that the later has experienced other geological processes. This sequence extends the upper limit of the previously reported Miocene loess-soil sequences at Qinan into the Pliocene, about 3.52 Ma BP. The 84 visually definable soils and loess layers in the section within a time coverage of 3.58 Ma suggest an average frequency of 42.6 ka for each soil-loess pair. This rhythm is consistent with the oscillations at 41 ka frequency of the late Miocene-Pliocene marine oxygen isotope record, attributable to the variations of Earth's obliquity. Up to date, geomagnetic measurements on the Hipparion Red-Earth Formation sections to the east of the Liupan Mountains dated the lower boundaries for 7 to 8 Ma BP. On the contrary, eolian deposits were well preserved since the early Miocene in the area west to the Liupan Mountains. A tectonic event would have occurred in the late Miocene time, leading to the formation of dust sedimentary basins in the eastern Loess Plateau.

MAGNETOSTRATIGRAPHY, LOESS, EOLIAN DEPOSITS, PLIOCENE

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Glacial and Interglacial signatures in lake deposits from northwestern China

Kai Hartmann, Bernd Wünnemann

A sediment core from the centre of the Gaxun Nur Basin, NW China provides evidence changes in water balance during the last glacial cycle. Millennial-scale and short-term variations of geochemical precipitates and grain size show that freshwater fluxes from the Tibetan Plateau by surface runoff were the main controlling factor for lake evolution in the dry forelands for the last

230 kyr. Periods of positive water balance with strong lake extension and reverse developments are in phase with changes in the ice volume of Tibetan glaciers and with Greenland ice masses, documenting the close relationship between environmental conditions in remote desert regions of NW China and orbitally forced northern hemisphere high mountain mid- and high-latitude climates on regional and global scale. We demonstrate that the East Asian summer monsoon are the major source for effective moisture supply. During the interglacial stage 5e summer monsoon moisture dominated owing to its strong northward shift beyond the modern limit. During interstadial climates, contemporaneous with D/O cycles in Greenland ice cores, both wind systems most likely supplemented each other, while in transitional phases moisture supply by the westerlies seems to have dominated. Cold-dry stages, recorded in the core, are synchronous with the global climate. They induced strong lake level declines and promoted eolian transport of exposed lake sediments due to the enhanced winter monsoon. Loess records from the Chinese Loess Plateau confirm that the temporal distribution of loess mobilization recorded in the Gaxun Nur sediments was synchronous with depositional phases on the Loess Plateau.

MIS 5, MONSOON, CHINA, LAKE SEDIMENTS, PALEOCLIMATE

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Research of diagenetic environment of Jiangbei conglomerate

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Jiangbei conglomerate is a kind of allothigenic supergene cemented rock that is widespread in the lower terrace of Quaternary sediment along the river in Sichuan Basin and its adjacent area, and consists of conglomerate and sandstone. The Jiangbei conglomerate belongs to river sediment and formed the basis of the lower terrace. It has its own characteristics different from other river sediment, namely it is cemented to solid rock. Up until now, the causes for its diagenesis were not researched clearly. We research its diagenetic environment using ^{14}C , ESR and U-Th dating methods and a series of analyses such as sediment chemistry, magnetic susceptibility, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ of its cemented material. On the basis of this research, we draw the conclusion that the arid and hot climate during the last stage of the late Pleistocene and early Holocene is the major cause of its diagenesis.

U-Th SERIES ESR ^{14}C DATING, C AND O ISOTOPES, OXIDE AND ORGANIC CARBON, DIAGENETIC ENVIRONMENT, JIANGBEI CONGLOMERATE

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Summer temperature lowering on the central Tibetan Plateau throughout the Holocene revealed by pollen spectra

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A 741-cm-long laminated sediment core, covering the last 11,400 years, was collected from Lake Zigetang (central Tibetan Plateau; 90.9° E, 32.0° N, 4560 m asl) and has been analyzed palynologically at 69 horizons. The *Artemisia/Cyperaceae* ratio, a semi-quantitative measure for summer temperature, yielded a general cooling trend throughout the Holocene. However, a suitable balance of wet and warm conditions for optimum vegetation growth likely occurred during the middle Holocene (7.9 - 4.8 cal ka BP) as indicated by dense temperate steppe vegetation and maximum desert plant withdrawal. Several short-lasting cold events have been reconstructed for 10.9, 10.4, 9.9, 9.1, 8.0, 6.0 and 4.2 cal ka BP. Generally, the Early Holocene is characterized by strong climate instability, while rather stable conditions were recorded for the Mid-Holocene and Late Holocene.

PALEOCLIMATE, TIBETAN PLATEAU, HOLOCENE, POLLEN ANALYSIS, ABRUPT CHANGES

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Grain size character of loess in Kulun County, Inner Mongolia, and its climatic implication

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The Kulun county in Inner Mongolia is located in the southwestern Northeast district. South of Kerqin Sand thick deposits of loess are formed since Neogene times. Research on the grain size distribution of the Kulun loess indicates that the same kind of loess was also formed during cold ice age period of the quaternary. Thermoluminescence ages of the loess in Kulun show that the deposition of loess began at least during the Miocene and that the mean deposition rate was about 7.3 cm/ka. Due to the particular geographical position of Kulun within the transition from temperate moist

areas to dry inland areas, the grain size distribution of the Kulun loess is different from that of the loess plateau. The grain size of Kulun loess is coarser than that of the Loess Plateau with a main grain size distribution between 40 μm and 95 μm . Based on field investigation and high-resolution investigations of grain sizes, the loess in Kulun area mainly comes from Kerqin sand. Profiles of Kd values and of medium grain size from the loess section in Kulun reflect variations of paleoclimate. The records show great fluctuations from the Miocene to Pleistocene that conform to paleoenvironmental reconstructions from pollen.

GRAIN SIZE ANALYSIS, CLIMATIC IMPLICATION, INNER MONGOLIA, LOESS, ENVIRONMENTAL CHANGE

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Study of magnetic fabrics in Chinese loess-paleosols since the last interglacial: Implication of the paleowind direction

Xiaogang Huang, Jimin Sun

The transportation and deposition of eolian materials of Chinese loess is correlated and effected by the monsoon from the mid-high latitude. And the research of the winter monsoon evolution can help us to understand the dynamic mechanism to climate change in the east-Asian areas. The anisotropy of magnetic susceptibility measurements of 220 samples from the loess profile of Baicaoyuan, Gansu province, all showed original magnetic fabric for sediments. We found that: 1) The degree of anisotropy(P) shows a strong correlation with the foliation(F) rather than with the lineation(L), therefore the anisotropy is controlled by the F; 2) The foliation is nearly horizontal and the axis K3 is perpendicular to the horizontal plane correspondingly; 3) Mostly values of the shape parameter(T) are in the area $0 < T < 1$ and correspond to the oblate shape of the magnetic ellipsoid; 4) The AMS features between loess and paleosols are somewhat different. The average value of F in loess is 1.007, while 1.004 in paleosols. The F, P values of paleosols are lower than that of its parent loess respectively. It is the pedogenesis that reduced or destroyed the primary fabric of the loess; 5) The average declination of K1 is 308.9°, which implies that the dominated wind direction at this site is NW since the last interglacial. This result presented here is the whole-effect of the wind field in this temporal span and the difference among the declination of K1 maybe correspond to the wind direction changes in different periods.

LAST INTERGLACIAL, MAGNETIC FABRIC, ANISOTROPY OF MAGNETIC SUSCEPTIBILITY, PALEOWIND

DIRECTION, WINTER MONSOON

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Sediment distribution patterns and evolution in the South China Sea since the Oligocene

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The sediment macro-distribution patterns and their evolutionary characteristics in the South China Sea (SCS) are discussed based on a quantification of the sediment mass since the Oligocene to present. Above the pre-Oligocene base, the total sediment mass for the whole SCS is 1.44×10^{16} t. The major part of sedimentation is on the continent shelf and slope where many sedimentary basins were developed. Basins with highest accumulation rates are not near the mouth of large rivers, but close to areas of active tectonics, confirms that the size of drainage basin is not but the uplift rate and the lithology of exposed rock in the source area are critical in determining sediment discharge from rivers. Local tectonic movement, global climate changes and other factors together controlled the sediment distribution patterns in the SCS. The accumulation rate was highest during the Oligocene when the SCS started spreading, then sharply decreased in the early and middle Miocene for quiescently tectonic activities, but increased again during the late Miocene especially in the south because of the uplift of the northern Borneo. After relative low rates were recorded for the Pliocene, the sediment accumulation accelerated in the north during the Quaternary affected by the increase of terrigenous supply from the continent due to glacial-interglacial variations of global climate change. The Oligocene is characterized by very low rates in the evolution of global sedimentation rates, but it has highest sedimentation rates in the SCS, indicating that the deposition of marginal seas is primarily controlled by local tectonics.

SEDIMENT DISTRIBUTION PATTERNS, ACCUMULATION RATE, SEDIMENT MASS, SOUTH CHINA SEA

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Paleotemperature reconstruction from the Late Quaternary deep-sea sediments based on oxygen isotope and alkenones data in the East Sea (Sea of Japan)

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Paleoenvironmental changes since the last ~250 ka was reconstructed based on the oxygen isotope compositions of foraminifera and alkenone data from the deep-sea sediments of the piston core (M04-PC1A) taken from the Korea Plateau in the East Sea (Japan Sea). Oxygen isotopic records of the planktonic foraminifera, that were estimated to be ca. 250 ka in age, show the Marine Isotope Stage (MIS) from 1 to 8. Comparing this result with previously reported stable isotope data in the East Sea as well as the global oxygen isotope trend, it is suggested that paleoceanographic and paleoclimatic changes in the East Sea has been quite different from those of open oceans: it reserves freshwater input signals and steep drop of paleotemperature (about 2‰ heavier) at the MIS 2.1 and 6.2, respectively. Paleotemperature variations of the surface water in the East Sea were reconstructed using unsaturated long-chain alkenones (ULA) along with oxygen isotope data. The result shows that paleotemperature was about 10°C lower than today's surface temperature during the MIS 6.2. However, paleotemperature during the MIS 2.2 was characterized by relatively small temperature drop of about 5°C. Both oxygen isotope and ULA data show the systematic coeval trend throughout the late Quaternary.

PALEOTEMPERATURE, OXYGEN ISOTOPE, ALKENONES, PALEOCLIMATIC CHANGES, EAST SEA

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Fire history reconstructed from microscopic charcoal analysis of sediments from Lake Biwa and adjacent areas, central Japan

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Charcoal fragments are generated by natural fires and anthropogenic fires. Because charcoal fragments are preserved in sediments and soils, charcoal analysis of accumulated sediments and soils can be used to reconstruct the fire history. Many studies on charcoal analysis have been carried out on Holocene sediments, however in Japan, fire history has not been proven sufficiently. We reconstructed fire history around Lake Biwa in central Japan from the late Pleistocene to present based on microscopic charcoal concentrations and influxes of sediments from Lake Biwa and

adjacent areas. The results show that the period of low fire frequency around Lake Biwa is from 136 ka to 13 ka cal yr BP in the late Pleistocene. The period of higher fire frequency is from 12 ka to 3 ka cal yr BP and decreases since 2 ka. Furthermore, the periods of highest fire frequency is from 11 ka to 8 ka yr BP. This study presumes that high fire frequency from 12 ka to 3 ka cal yr BP might be caused mainly by anthropogenic fires. Because, despite change of climate inferred from previous studies, charcoal concentration prior to 12 ka yr BP is continuous low and many early human remains dated back to approx. 10 ka yr BP have been discovered around Lake Biwa.

FIRE HISTORY, MICROSCOPIC CHARCOAL, LAKE BIWA, CENTRAL JAPAN, LATE PLEISTOCENE-HOLOCENE

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Provenance of eolian quartz in different size fractions of the Chinese Loess based on ESR signal intensity and crystallinity

Yuko Isozaki, Ryuji Tada, Shin Toyoda, Atsushi Tani, Youbin Sun, Kana Nagashima

Eolian dust deposited in the Chinese Loess Plateau is considered as derived from the dry and semi-dry area in the windward including Gobi and Taklimakan deserts. According to previous researches, it was suggested that eolian dust to the Chinese Loess Plateau was transported by the westerly wind and the winter monsoon wind. Sun (2004) analyzed the grain size distribution of loess in Chinese Loess Plateau and demonstrated that it has two components. He suggests that the coarse component is transported by winter monsoonal wind, whereas most the fine component is transported by westerly wind, and this wind variation linked glacial-interglacial cycles. However, he did not examine the provenance of coarse and fine components. Therefore, the change in the grain size can be also attributable to the change of the wind velocity. We examined the provenance of loess in Lingtai section of the Chinese Loess Plateau to test the hypothesis of Sun. We first analyzed grain size distribution in Lingtai section. Next, according to the obtained grain size distribution, we separated loess samples into 2 size fractions 0 - 30 μm and >30 μm , and measured the ESR (Electron Spin Resonance) signal intensity and crystallinity of the quartz in each fraction. From this result, we try to specify the provenance of eolian dust in each grain size fraction of loess in Lingtai section of the Chinese Loess Plateau.

EOLIAN DUST, WESTERLY WIND, WINTER MONSOON WIND, ESR SIGNAL INTENSITY, CRYSTALLINITY

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Shoreline changes in the upper Gulf of Thailand: Past, present and future

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The position of shoreline in the upper Gulf of Thailand is dominated by the influx of sediments by rivers, the tectonic movements and the sea-level changes. The morphology of the shoreline of the coastal lowlands is strongly influenced by the tidal and wave regime. From 15,000 years BP until about 6000 years BP most of the landwards shorelines shifting is dominated by the restoration of ocean level due to the melting down of the land ice caps. During this period shorelines of the upper Gulf of Thailand move landwards: transgressive shorelines. After 6000 years BP the position of shoreline was dominated by tectonics, geoid changes and to a lesser degree to glacial eustasy. This resulted in an alternation of regression and transgressive shorelines. The shorelines in these areas contains sediments from the four major rivers and forms a soft and muddy shore. Recently, some part of it subject to severe erosion and the loss of the coastal lowland is in consequence. The results of the study reveal that there are many evidences of coastal impact along the upper Gulf of Thailand. Very severe coastal erosion with rates of more than 25 m/year occur on the west coast of the Chao Phraya river mouth. High coastal erosion with rate between 10-25 m/year occur on both sides of the Chao Phraya river mouth. The shorelines at the head of the upper Gulf of Thailand in the vicinity of the Chao Phraya river mouth has suffered from the attack by waves from the South with the maximum eroded distance of 1 km from 1969 to 1997. Human intervention affecting coastal erosion in the upper Gulf of Thailand has taken place to a significant level over the past 30 years. The wide-scale land subsidence and upstream damming has been to increase the severity of coastal erosion along the upper Gulf of Thailand.

SHORELINE, CHANGES, PAST, PRESENT, FUTURE

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Reconstruction of climate and vegetation changes for Lake Bayanchagan (Inner Mongolia): Holocene variability of East Asian monsoon

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High-resolution pollen and *Pediastrum* records over 12,500 cal yr BP were present from the Lake Bayanchagan (115.21°E, 41.65°N, and 1355 m asl), Inner Mongolia. Two concepts of the best modern analogues technique, based on individual pollen taxa (PT-MAT) and the PFT affinity scores (PFT-MAT), respectively, were used to attempt a quantitative climatic reconstruction from pollen data. Two methods indicate similar main climatic patterns. Before 10,500 cal yr BP, a cold and dry climate prevailed, comparable to the present climate. Annual temperature and precipitation increased after ~10,500 cal yr BP and *Pediastrum* curve rose in abundance as well indicating high lake levels. The annual precipitation increases up to 40% higher than for the present-day and an annual temperature up to 5°C higher. Deciduous forest patches were important from ~8000 to ~6500 cal yr BP. Both methods show that precipitation estimates decrease quickly around 6500 cal yr BP; steppe was re-established as a dominant vegetation type. The increased aridity is confirmed by a fall of the *Pediastrum* abundance, indicating a drop of lake level soon after 6000 cal yr BP. The mid-Holocene cooling started at about 8000 cal yr BP, while the drying started 1500 years later. Patterns of vegetation and climate in Inner Mongolia over the Holocene probably reflect expansion and shrinkage of the East Asian monsoon. Inner Mongolia is situated at the limit of the present East Asian monsoon. The early to middle Holocene monsoon certainly reached much more northern latitudes than the present.

POLLEN DATA, PALEOCLIMATE, VEGETATION, EAST ASIAN MONSOON, HOLOCENE

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Temporal and spatial changes of vegetation cover on the Chinese Loess Plateau through the last glacial cycle: Evidence from spore-pollen records

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To reconstruct the paleovegetation cover of the Chinese Loess Plateau over different time intervals of the last glacial-interglacial cycle, the spore-pollen representation of loess-soil samples in six loess sections including Jiyuan, Mubo, Qingyang, Ningxian, Binxian and Lantian along a north-south transect is analyzed and previously-published pollen data reviewed. Results show that the temporal changes in the vegetation cover of the Plateau are controlled essentially by the history of the East-Asian summer monsoon and there is a general pattern that the pollen components indicating relatively humid climatic conditions such as trees, ferns and algae, and mesic herbs are better represented during interglacial and interstadial periods than during glacial and stadial periods. The herbaceous pollen concentrations show a general increase from south to north with the decrease of monsoonal precipitation over the Loess Plateau and the proportion of trees, ferns and algae, and mesic herbs show reversal changes. Through the last 130 ka or so, the main body of the Loess Plateau has been covered by an *Artemisia*-dominated grassland vegetation, suggesting that future rehabilitation of the landscape that aims for soil-water preservation on the Loess Plateau should focus on the planting of herbs.

LOESS DEPOSITS, POLLEN RECORD, GRASSLAND, LAST GLACIAL CYCLE, CHINESE LOESS PLATEAU

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200,000 year record of carbon isotope from the South China Sea

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A stacked carbon isotope record of 200-kyr is established on the basis of planktonic foraminifer $\delta^{13}\text{C}$ (*Globigerinoides ruber*) from 8 sites in the South China Sea (SCS). Comparing 200-kyr planktonic $\delta^{13}\text{C}$ records from the South China Sea, western Pacific Ocean, Indian Ocean, northern Atlantic Ocean and Southern Ocean, they have the similar change direction. The $\delta^{13}\text{C}$ record from the SCS displays a trend toward more positive values from MIS6 and 4 to MIS2, which is related to the later part of a long-term 500-kyr cyclicity in oceanic carbon reservoir, and it suggests that the Earth is entering into the $\delta^{13}\text{C}_{\text{max}}$ phase. The 200-kyr carbon isotope record of the SCS shows obvious glacial/interglacial cycles, with three significant $\delta^{13}\text{C}_{\text{min}}$ events, occurring at glacial terminations (MIS1/2, MIS3/4,

MIS5/6). Probably, this results from the expansion of terrestrial vegetation during the deglaciation. The good coherence between the 200-kyr $\delta^{13}\text{C}$ record and the June insolation (30°N) indicates the role of low-latitude processes in oceanic carbon reservoir changes.

SOUTH CHINA SEA, CARBON ISOTOPE, CARBON CYCLE

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Environmental change during the Holocene in the northeast district, China

Dongmei Jie, Ke Hu

The northeast district, China is located on the transitive belt between forest and steppe and is very sensitive to environmental change. A change in the ratio of needle-leaved and broad-leaved plants, trees and herbs in the east, a change in the amount of chenopodiaceae and the ratio of trees and herbs in the west, and the change in the transition between forest and steppe are all obvious in the northeast district in different periods during the Holocene. The shifting of the 40% tree and 1.0 dryness degree and 600 mm precipitation isolines shows repeated changes in the pattern of temperature and precipitation distribution. There are three obvious temperature stages in the northeast district during the Holocene, and several events of declining temperature. The speed of temperature rise was generally faster than that of temperature decrease. Different precipitation in different periods during the Holocene are apparent: two drought periods between 7260-5400 yr BP and 3600-2700 yr BP, and humid periods during 10,250-7260 yr BP, 5400-3600 yr BP and since ca. 1500 yr BP. There are quite different precipitation regulations between the east and the west, e.g., precipitation in the west has decreased since 7000 yr BP.

ENVIRONMENTAL CHANGE, HOLOCENE, NORTHEAST DISTRICT, TRANSITIVE BELT, CHINA

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An early-Pleistocene environment of a Tibetan lake related to climatic change and tectonic activity

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To better understand the Tibetan-Himalayan uplift and its connection to monsoon circulation and drying processes of internal Asia, the determination of the time and duration of uplift is essential. Much effort

has been invested during the last decades in studying sedimentation in the Bengal Fan and loess deposition in association with the uplift, however little evidence come from internal plateau till now. The study of ancient, tectonically forced, small lacustrine systems may help to unravel some aspects of the long- and short-term environmental change of basins in association with tectonics, morphology and climate. Here, we present an early-Pleistocene lacustrine record from a long lake sediment core from a tectonically-driven basin in the central Tibetan Plateau. Paired measurements of trace elements (Mg/Ca, Sr/Ca) and stable isotopes ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) in ostracod shells, along with palynological and sediment data show distinct environmental oscillations in associated with tectonic uplift at 1.16 Myr and climatic change over the period 0.9 to 2.0 Myr. Variations of ostracod and pollen records correlate well with three drying during early Pleistocene, the last one that was accompanied by a tectonic uplift.

TIBET, CLIMATE, LAKE SEDIMENT, OSTRACOD, TECTONIC ACTIVITY

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Reconstruction of Late Holocene Northeast Monsoon from pollen analysis of sediment sections in a rain-fed irrigation reservoir, Tamil Nadu, India

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This study tries to understand the past dynamics of the North East Monsoon (NEM), a regime hardly studied in the Indian sub-continent. Sediment succession from Parambu Kanmai (10°06'N; 78°18'E), a rain-fed reservoir in the NEM regime was chosen for this study of paleoenvironmental changes. The first results from luminescence and radiocarbon dating of the sequence suggest its existence since ~7 ka. The pollen record of 2 sections (~2.5 m), consisting of bands of clayey sand and sandy sediments was examined. The clayey sands were richer in palynomorphs. Over 60 distinct pollen taxa, belonging to around 30 families were identified. The pollen assemblages of the surface samples reflect the present-day vegetation in the catchments and basin, where remote sensing analysis shows minimal disturbance. This is validated by the near absence of pollen markers such as Casuarina and Cocos. The frequency and occurrence of other markers conform to present day non-stagnant conditions. In the topmost clayey coarse sand layer, pollen analysis shows increasing dryness from around 300 yr to the present. The variation in Cyperaceae along the

section was used to understand fluctuations in past rainfall, including higher rainfall/storm surge events. Corresponding variations in forest pollen from the catchments (of which a definite increase is noted at around 3 ka) further support this. A reconstruction of the late Holocene environment history of this NEM area, validated by other proxies, will be presented.

NORTHEAST MONSOON REGIME, SEDIMENT SUCCESSION, POLLEN, PALEOENVIRONMENT, LATE HOLOCENE

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Late Quaternary terrestrial wetland depositional sequences in South Korea

JuYong Kim

The late Quaternary wetland depositional sequences covers sedimentary sequence and pedological sequence of last interglacial, last glacial and Holocene sequences. The sequences of Ilsan coastal areas, Soro-ri sites, Mokpo-Mongtan areas, Jangheung-ri sites, and so on, were exemplified in the contexts of sedimentary facies, grain size, organic geochemistry, magnetic susceptibility and carbon radiometric datings and pollen analysis. Sedimentary sequence of last interglacial is typified by thalassostatic terrace sequences, which are represented by conspicuous fluvial gravel sequences, showing outstanding flat surfaces above 10-20 m over present downstream riverbed. Last interglacial pedological sequence is characterized by reddish brown pedo-sequence. It is commonly overlain by less-weathered and brown to yellowish brown pedo-sequence or dark brown pedo-sequence of the last glacial period. The last Glacial sedimentary sequences are composed of old fluvial sequences (pre-LGM), Slope Deposits of pre-LGM, brown to dark brown paleosols of pre-LGM and during-LGM period, as well as Young Fluvial Sequences (post-LGM). Lastly the Holocene sequences are constituted by young paleosol sequence of early Holocene, as well as backswamp-flooding sequence and anthropogenic sequence of middle to late Holocene. Particularly, flooding sequences are intermittently intercalated with later pedogenetic horizons, which were formed in relation to local hydrological fluctuations and human interventions in riverine and riparian areas. The

anthropogenic sequences are evidenced by cultural relics, including potteries, early human settlements and cultivation remains. Some remnants of old land management since the Bronze Age (ca. 3,500 yr BP) were found as an ancient human intervention on the wetland environment, i.e., reclaiming cultivation land at maximum extent.

LAST INTERGLACIAL, LAST GLACIAL MAXIMUM, HOLOCENE, WETLAND, SEDIMENTARY SEQUENCES

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Holocene climate change around the northern foot of Mt. Fuji, central Japan

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In an attempt to reconstruct the pattern of Holocene climate change in central Japan, a 17.63 m long boring core was extracted from the deepest part of Lake Yamanaka, one of the Fuji Five Lakes at the northern foot of Mt. Fuji. The core mainly composed of clayey and sandy silt with intercalations of scoria fallout deposits at more than 40 horizons, which accounted about half of the core length. The sediment was investigated for total organic carbon (TOC) and total nitrogen (TN) contents and grain-size variation as climate proxies. Sediment chronology derived from tephra and radiocarbon ages yielded sedimentation rate in a range between 2.73 mm/yr and 0.68 mm/yr. The TOC content and grain-size distribution showed various degrees of fluctuations, and are closely negatively correlated in both short- and long-term fluctuations. Surface water temperature and paleohydraulic changes in and around the lake appear to be the main factors affecting the variability in TOC content and grain-size distribution. Climatic events such as the modern warming, the Little Ice Age (LIA), the Medieval Warm Period (MWP), and the Holocene Optimum (HOP) together with some other warm and cold events are evident. The study also reveals the volcanic history of Mt. Fuji during the Holocene.

MT. FUJI, LAKE YAMANAKA, ORGANIC CARBON, GRAIN SIZE, HOLOCENE

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Mangrove deposits as paleomonsoon archives of the Late Quaternary on the west coast of India

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India has a coastline of ~6,500 km with mangroves covering ~4,87,100 ha. Mangroves occurring as laterally continuing belts help trap fine-grained sediments, including spores and pollen because of their unique and intricate root network system. Preservation of such sediments in the geological column helps yield information on the ambient sea level, presence and extent of brackish water bodies, swamps and marshes. However, our observations suggest that the mangrove deposits can be excellent indicators of abnormal paleoclimatic events such as excessive and deficient rainfall. Excess rainfall leads to disproportionate erosion of the catchment areas and the sediments deposited by such floods over decades and centuries can cause phenomenal changes in the substrate lithology. More importantly, in regions of low subsidence rates, estuaries and lagoons get silted up and can turn into swamps and marshes beyond the reach of tidal waters. Thus, two of the most important parameters required for the survival of mangroves, namely salinity and substrate, can become non-existent through excessive rainfall. On the contrary, deficient rainfall over a long period can turn the brackish water bodies and other coastal landforms that support the mangroves progressively more saline, greater than the tolerance level of the mangrove flora. These environmental changes due to changing rainfall can indeed become much more complex through fluctuating sea levels and tectonics. Therefore, it is clear that mangrove deposits can be potential records of large-scale variations in rainfall history. Here, we deal with Quaternary sediments of the southwestern coast of India between 9° and 20°N.

MANGROVE DEPOSITS, LATE QUATERNARY, PALEOMONSOON, WEST COAST, INDIA

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The retreat of Tien Shan glaciers (Central Asia) since the "Little Ice Age" obtained from moraine positions, aerial photographs and satellite images

Stanislav Kutuzov

The retreat of the terminus of glaciers and loss of glacier's area from their maximum extent during the "Little Ice Age" (LIA) maximum (17th-19th centuries) have been estimated using aerial photographs from 1956 to 1987 and the latest satellite images from 2001 to 2004 from

the central Tien Shan mountains (Kyrgyz Republic). In order to increase the accuracy in the identification of the moraines at the satellite and aerial images, all kinds of published information about the front positions of glaciers at the end of the 19th century was used. The glaciers under investigation are located on Teskey Alatau, Ak-Shyrak, Adir-Tor ranges. There is a great diversity of types, exposure and size of glaciers in the research area. On average, the glaciers in these areas have retreated by 900-600 m since the LIA maximum. Thus in the second part of the 20th century, glaciers area has changed by about 25-30% compared to 5-8% between 1880 and 1970s. Unprecedented wastage of glaciers in the Tien Shan from the mid-1970s till the beginning of the 21st century most likely resulted from the increase of summer air temperature and decrease of summer precipitation, which have been recorded at meteorological stations (e.g., the Tian Shan station). Changes in atmospheric pressure over the central North Atlantic Ocean during the mid-1970s can be one of the possible reasons for these processes. The study was supported by the ISTC grant #2947.

TIEN SHAN, GLACIER RETREAT, SATELLITE IMAGES, LITTLE ICE AGE, CLIMATIC CHANGES

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Influence of climate changes on primary occupation of Northern Asia by Paleolithic Man

Stanislav Laukhin

At first Southern Mountain Belt of Siberia (SMBS) was settled. Most ancient sites of SMBS were known on East – Zasukhino in Transbaikalia since 900-800 ka and West – Mokhovo 1 in Kuznetsk basin ca. 500 (600?) ka. In SMBS Men used fire yet in Middle Pleistocene – sites Zasukhino 400 ka, Denisova cave ca. 224 ka, Ust'-Izul' 1 ca. 190-180 ka. The big variegated environment in mountain provided possibility for exploration favorable ecological niches. The net results was that habitation occurred only in circumscribed, separated areas. The relative stability of these niches environment may have allowed by Middle Pleistocene settlers of SMBS to achieve high level of specialization. This factor militated their further settlements in areas beyond SMBS (and farther the North). Such situation was remained till Maximum Ice ca. 300-250 ka. During Maximum Ice quantity of favorable niches diminished. In local areas, which were suitable for Men living, can begin demographic oversatiation. Therefore, ca. 260-250 ka on transition from Maximum Ice to follow interglacial began mass settling in SMBS. In SMBS were opened many favorable niches. However according to "principle of spring" Men settled not only in SMBS, but had place penetration of Men to North from SMBS: Diring-Yuriakh, Ust'-Olekma, etc. on Lena; Igitey 1, etc. in upper stream of Angara, may be (Dikov, 1993) sites on Chukotka. This wave of migrations didn't lead to settlement of big regions to North from

SMBS, because in this time SMBS was inhabited very poor. Slow settlement of SMBS continued until Middle Warm. Full demographic satiation of SMBS had place ca. 35 ka. Konoshelian cooling ca. 33-30 ka resulted to demographic over-satiation in SMBS. During this cooling climatic, biotic and landscape conditions in SMBS was the same as in Middle-Siberian Tableland, etc. to NE Asia. It was reason Men leaving SMBS and spread to NE Asia from SMBS. Till Last Glaciation (24-10 ka) Men assimilated uplands of East and NE Asia, where environment was also mosaic like SMBS. Last Glaciation was reason of demographic satiation on uplands of Northern Asia. Only past it, since 16(18 ?) ka colonization of Western-Siberia Plain began.

NORTHERN ASIA, CLIMATE, SETTLEMENT

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Paleoclimate changes over the last 2000 years at Jiuyenhai area, Inner Mongolia, China: Evidence from environmental magnetic study

Teh-Quei Lee, Hwei-Fen Chen, Sheng-Rong Song, Yong Wang, Zen-Qing Chi

An 4.3 m core, named as JYH-C retrieved from east Jiuyenhai was analyzed for paleoclimate changes study by employing the environment magnetic method. ¹⁴C datings and paleo-intensity data were used to reconstruct the age model of this core. It is pointed out that this core provides the information for the last 2000 years. Proxies, such as magnetic susceptibility (*c*), isothermal remanent magnetism (IRM) and anhysteresis remanent magnetism show that relative abundant magnetic minerals were deposited around 600-700 yr BP, 1450-1530 yr BP and 16770-1730 yr BP, which might represent that many wet seasons happened during these time periods. On the contrary, much less magnetic minerals could be found during 1000-1100 yr BP, 1300-1400 yr BP and 1850-1950 yr BP, which probably represent much drier seasons. In addition, other proxies such as the hard component of the saturated IRM and S-ratio, which reflects the relative abundance of different magnetic minerals, and ARM/k reflecting grain size variation, point out that more oxidized and/or coarse grained magnetic minerals appeared to be associated with the periods when less magnetic minerals were dominant. These environmental magnetic parameters suggest quite frequent climate changes during the last 2000 years in the area studied.

ENVIRONMENTAL MAGNETISM, PALEOCLIMATE, JIUYENHAI, LACUSTRINE SEDIMENTS

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Ancient DNA dislikes warmth—why we fail to retrieve ancient Panda's DNA

Tao Li

Ancient DNA allows for a novel approach to explore genetic information from fossils. However, It is very difficult to retrieve trace DNA from ancient material. Theoretically, researchers can extract and amplify the target DNA from well-preserved material that is not older than 100,000 years. But this rule does not apply to fossils that are preserved in a hot and wet environment. The author of this paper tried many times to extract and amplify ancient DNA from Late Pleistocene Panda in southern China. Unfortunately, no target DNA sequence came out of those repeated experiments. The research material from Zhenxiong County, Yunnan Province, was dated to be from 20,000 yr BP. The key to retrieve ancient Panda's DNA is the material's "hot history". In other words, researchers have to consider the annual average environmental thermal history of the material from its embedding until present. It is well known that the climate in Southern China was hot and wet since the Late Pleistocene. In such environment DNA damages quickly. It is therefore inappropriate to search for ancient DNA in Southern China. Instead, for analysis of fossil DNA researchers should focus on material preserved in cold environments.

ANCIENT DNA, PANDA, SOUTHERN CHINA, LATE PLEISTOCENE

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Phytolith morphology in Bambusoideae and its ecological significance

Quan Li, Houyuan Lü

It is well known that China is the "Country of Bamboos". And bamboos are very sensitive to the environment. The distribution of bamboos has always changed with the climate and soil-water-thermal condition. But we can hardly find bamboo fossils such as leaves, stalk and rhizome from strata for the difficulty in preservation, and bamboo pollens are too difficult to identify that researchers always sum up pollens from Gramineae as one type. How can we trace the vicissitude and distribution of bamboo forest in history? Systematic morphological research on phytoliths is done to 63 species 19 genus in Bambusoideae. Long-saddle phytoliths diagnostic in bamboos are measured to get configuration parameters such as length, width, height and the amount of silica granules on the surface. Based

on the classification of four ecotypes among different bamboos in genera level, these observation work reveal that average size of long-saddle phytoliths from sympodial scattering bamboos is the largest (Length: $20.6 \pm 0.2 \mu\text{m}$, Width: $12.8 \pm 0.5 \mu\text{m}$, Height: $12.4 \pm 0.1 \mu\text{m}$, Granule Amount: 2.5 ± 0.6) with monopodial scattering bamboos larger (L: $18.8 \pm 0.8 \mu\text{m}$, W: $11.7 \pm 0.4 \mu\text{m}$, H: $11.8 \pm 0.3 \mu\text{m}$, GA: 1.9 ± 0.1), then the compound mixed bamboos (L: $18.3 \pm 1.5 \mu\text{m}$, W: $11.2 \pm 1.5 \mu\text{m}$, H: $11.4 \pm 1.7 \mu\text{m}$, GA: 1.8 ± 0.4), and the smallest is size from sympodial caespitose bamboos (L: $18.0 \pm 1.8 \mu\text{m}$, W: $9.7 \pm 0.5 \mu\text{m}$, H: $10.1 \pm 1.4 \mu\text{m}$, GA: 2.6 ± 0.3). Discriminant analysis on morphological variables of long-saddle phytoliths also plot out these four ecotypes. Corresponding connection between phytoliths and ecotypes of Bambusoideae is founded with morphological classification. And the relationship between long-saddle phytoliths and habitat of Bambusoideae is discussed as an index to reconstruction of paleoenvironment, along with the significance of long-saddle phytoliths in evolvement sequence of Bambusoideae.

BAMBUSOIDEAE, LONG-SADDLE PHYTOLITH, ECOTYPE, DISCRIMINANT ANALYSIS

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Progress in studies of cave stalagmites in China and other countries

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Research on speleothems is a new hot topic in the study of the Quaternary environment. Because of their special superiorities and characters, stalagmites have been one of the most important recorders of climate changes. The study of stalagmites benefits from the research on coral deposits. Here, we review the progress of basal mechanisms in stalagmite research, especially the progress of stable isotope, trace element and micro-bandings, and emphasize the importance of basic research in the study of climate changes. In China and other countries, a series of abrupt climate events have been discovered through records from stalagmites, such as. These regional events correspond with Dansgaard-Oeschger and Heinrich events and the Younger Dryas from other climate records such as ice-cores. Paleo-environment has been reconstructed in different regions on different time-scales. But there is still some deficiency in the research of stalagmite, for example, the quantitative research is not very precise, the analytical resolution should be improved and the relationships between stable isotopes and environmental change are still not clear. Considering these problems, we should strengthen the experiment and observation work, the basic research, extend the

study regions, make certain the key research period and reinforce the comparison of climate reconstructions from different regions and different records.

STALAGMITE, TIMS-DATING, STABLE-ISOTOPE, TRACE ELEMENTS, MICRO-BANDING

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Holocene environmental and climatic change events derived from a meromictic lake sediment record on the Tibetan Plateau

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Zigetang Lake ($32^{\circ}00' - 32^{\circ}09'N$, $90^{\circ}44' - 90^{\circ}57'E$) is located in central Tibetan Plateau, which is a closed alkaline and saline lake with pH value of 10. The elevation of water surface is 4560 m asl with an area of 190 km² and a maximum depth of 39 m. Investigation results revealed that it is a meromictic lake, which might be a highest one in the world. The feature of thermocline and chemocline existed simultaneously could be stratified this lake water column into three strata: 0-10 m, 10-22 m and below 22 m. It is widely accepted that meromictic lakes are favorite sites for varve formation and preservation. In the past years, we have drilled some cores at the central lake and found the well-preserved laminated sediments. Of which, a 7.4 m long core provides continuously and detailed information for climatic and environmental changes during Holocene period. The age of about 9500 cal yr BP at the core bottom has been revealed by the AMS ¹⁴C dating using the chitin material in the laminated layers and the chronological stratigraphy has been reconstructed by the methods of ¹³⁷Cs, ²¹⁰Pb and ¹⁴C AMS dates. Multiproxies of the sediments for potential high-resolution paleoclimate records, such as stable isotope, authigenic carbonates, grain-size, geochemistry, sedimentation rate, dissolved salt composition, ostracods and so on, have been analyzed. The results show that water level of the lake had several sudden changes during the Holocene period. The status of high lake level during cord period in Holocene implies the more precipitation, which indicates the southwest monsoon (Indian Monsoon) getting stronger that is in the reversal of the conditions of the southeast monsoon (Pacific Monsoon).

VARVED SEDIMENTS, HIGH-RESOLUTION RECORD, HOLOCENE CLIMATE CHANGES, SOUTHWEST MONSOON, TIBETAN PLATEAU

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Fine eolian dust flux changes in East Asia during the last 6500 years and their implications of westerly wind migration

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The dominant forcing factors on westerly wind circulation and related wind-driven (eolian) dust activity in East Asia during the Holocene have not been well determined despite their high significances. Here, we present a high-resolution eolian quartz records with bimodal size distribution in a maar of Cheju Island, Korea, during the last 6500 years. Time series of fine particle flux, which is sensitive to the position of the westerly winds for high altitude and/or long distant transport, reveals centennial-scale variability with periodicities of ~800, 400, 320, 210, and 170 year. The pattern and timing of fine flux variations bear a striking resemblance to those of the atmospheric temperature in Greenland, showing that the high/low fine flux corresponds to warm/cold temperature records in Greenland ice cores, and this suggests northward/southward migrations in the westerly winds in East Asia. Cross-spectral analysis provides significant coherent cycles at ~840, ~320, and ~200 (de Vries cycle) year. Our results demonstrate that the centennial-scale northward/southward migration of the westerly winds may have been affected by solar activity and rearrangement of atmospheric-oceanic circulations, leading hemispheric simultaneous centennial climatic events during the last 6500 years.

EOLIAN DUST, WESTERLY WINDS, EAST ASIAN MONSOON, GREENLAND ICE CORES, HOLOCENE

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Study on the growth rate of cave stalagmites

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The growth rate in the stalagmite is an index that recording the warm and cold of paleoclimate evolution, which has been mainly considered through the synthetical study in large stalagmite sections, synthetic dating of the representative sections and the typical part and research on the calculation rate of stalagmites in Yunnan, Guizhou, Hunan, Guangxi provinces, China. The growth

rate is over 10 mm every 100 years, which should grow during the warm humid climate in the interglacial or postglacial period, while that of stalagmite is 1 mm every 100 years or less that indicate the change process from the warm humid to cold climate period or the deposit of the cold stage. When the growth rate is about 1 mm every 100 years represents the sediment of the cold climate in the glacial period, if that of stalagmite is close to 10 mm every 100 years should be the change process from cold climate in the glacial period to warm humid climate period or sediment in the interglacial period. The minimal growth rate is often indicating sediment in the cold climate, and shows the sudden change point of climate and geology, such as abrupt events. The hiatus of stalagmite is very common; in particular the hiatus in the glacial period is more frequent. The observation and dating have indicated that the accumulative time of the hiatus account for 28.92~76.26% in those stalagmites and the hiatus time of the warm climate in Holocene is only 13.80%.

STALAGMITES, GROWTH RATE, PALEOCLIMATE

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Changes in grain-size and sedimentation rate of the Neogene Red Clay deposits along the Chinese Loess Plateau and implications for the paleowind system

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This report aims to investigate spatial-temporal changes in grain-size and sedimentation rate of the Neogene Red Clay deposits in north China and to explore paleoclimatic changes during the late Miocene and Pliocene, in particular the paleowind system that transported dust. Samples were collected from eight Red Clay sections on the Loess Plateau. Measurement and analysis show there is a clear southward decrease in the mean grain-size index and in the coarse particle fraction (>20 μ m). This distinct diversity of grain-size in the eolian Red Clay deposit between the north and south indicate that the paleodust was transported mainly by northerly low-level winds. The grain-size variations in the Red Clay deposits can also be divided into three stages: grain-size of the lower stage is significantly coarser than that of the middle stage, but finer than that of the upper stage. As a consequence, the intensity of paleowind and desiccation of the dust source region during the late Miocene and Pliocene can be divided into three stages. Strength of the paleowind during the middle stage (5.4-3.5 Ma) is weaker than that of the previous and subsequent stages

and the intensity of paleowind during the latest stage (3.5-2.6 Ma) is stronger than that of the early time (6.2-5.4 Ma). Variations in sedimentation rate of the Red Clay deposit can also be divided into three stages: the earlier, the middle and the later intervals. The sedimentation rate of the earlier stage is higher than during the middle stage, but lower than during the later one.

RED CLAY DEPOSIT, GRAIN SIZE, SEDIMENTATION RATE, ATMOSPHERIC CIRCULATION, LATE MIOCENE AND PLIOCENE

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Lake Van Drilling Project "PALEOVAN" - a new ICDP initiative and PAGES-PEP III contribution

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Lake Van (eastern Anatolia, Turkey) is an excellent paleoclimate archive. In 1990, during a German-Swiss expedition, high-resolution hydrochemical, geochemical, geological and biological investigations of Lake Van were carried out. Results of continuous records of varve thickness, geochemistry, $\delta^{18}\text{O}$, $\delta^{13}\text{C}$ and pollen were used to distinguish eight different climate phases during the last 14,700 years. Further progress in obtaining longer sediment records of Lake Van can only be achieved by focusing national and international experience and expertise under the umbrella of ICDP. Following the successful realization of a seismic cruise and coring campaign for a set of new cores in 2004, we will organize an ICDP funded PALEOVAN workshop in spring 2006. The aim of this workshop is a discussion of the state-of-the-art and the planning of drilling strategies with the equipment GLAD800. A further aim is to identify a group of international scientists from different research fields who will actively be involved in the project. Specific goals of the proposed PALEOVAN project are to reconstruct: (1) Paleoclimate development in a sensitive semiarid region based on transfer functions (pollen, stable isotopes) and modeling (2) Climate variability in space and time based on teleconnection with other high-resolution records such as ice cores and marine sequences (3) Dynamics of lake level fluctuations (4) Formation and age of Lake Van (5) History of volcanism based on tephrostratigraphy (6) Variations of the earth-magnetic field (7) Tectonic, paleoseismic and earthquake activities (8) Interaction between man and environment since prehistoric time

LAKE SEDIMENTS, PALEOCLIMATE

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Comparison of the bulk organic carbon isotopic records of Sihailongwan Maar Lake, NE-China and Huguangyan Maar Lake, SE-China and their paleoclimatic and paleoenvironmental significances since the Last Glacial

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Sihailongwan Maar Lake and Huguangyan Maar Lake are located in NE- and SE-China, respectively. East Asian Monsoon influences them both. The bulk organic carbon isotopic compositions of both lakes are analyzed to study on East Asian Monsoon changes since the Last Glacial. The organic carbon isotopic compositions curve of Sihailongwan Maar Lake displays millennial-scale climatic fluctuations during the Last Glacial and relative stable climate during the Holocene. Since 18 cal ka BP, the curve can be divided into three parts. 18 cal ka BP~15 cal ka BP, the organic carbon isotopic compositions are relative heavier; they become much negative during the Last Deglaciation (15 cal ka BP~11 cal ka BP). During the Holocene, the variation of organic carbon isotopic compositions is small. These reflect stable climatic condition during the Holocene in contrast to frequent changes during the Last Glacial. There are six stages of organic carbon isotopic compositions of Huguangyan Maar Lake since 62 ka BP. During 62~58 ka BP and 48~40.5 ka BP, they are much more negative, indicating two paleoclimatic periods of warmth and humidity. In contrast, during 58~48 ka BP and 40.5~17.2 ka BP, the paleoclimatic conditions became much drier and colder, with significantly heavier values. Since 17.2 ka BP, there is tendency of gradually lighter values in spite of much high frequency oscillations. After 4 ka BP, the values became heavier, which maybe indicator of increased drought. Based on comprehensive analysis, the virtual precipitation is the key factor that controls the C3/C4 relative plants biomass around Huguangyan area. This result supports that regional climate change instead of atmospheric CO_2 as the dominant control factor on glacial-interglacial variations in C3 and C4 plant relative abundance in tropical low latitude area.

BULK ORGANIC CARBON ISOTOPIC RECORDS, HUGUANGYAN MAAR LAKE, SIHAILONGWAN MAAR LAKE, EAST ASIAN MONSOON, LAST GLACIAL

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Magnetostratigraphy of the Miziwan Miocene eolian deposits

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Earlier studies on two sections (QA-I and QA-II) in Qin'an County from the western Loess Plateau demonstrated that loess deposits started by 22.0 Ma BP, indicating the onset of Asian desertification and winter monsoon circulation by the early Miocene time. Another Miocene loess section, Miziwan section with a thickness of 164.4 m, 30 km in east to QA-I section, is geomagnetically dated in this study. Thermal demagnetization was performed on 898 oriented samples collected from Miziwan section at an interval of 20/25 cm. Samples were demagnetized in a MMTD-60 Thermal Demagnetiser and measured using a 2G three-axis cryogenic magnetometer, both installed in field-free space. The progressive demagnetization on 118 representative samples at a temperature range of 100°C to 680°C shows that the characteristic remnant magnetization (ChRM) can be isolated between 350°C and 550°C. To improve efficiency, other 780 samples were demagnetized between 250°C and 525/550°C. The obtained magnetozones of Miziwan section can be well correlated with the geomagnetic polarity timescale (GPTS) of chrons C5r.3r to C5En. Extrapolation based on sedimentation rate indicates a time span of the sequence from 11.6 Ma to 18.5 Ma BP. The basal age of Miziwan section is younger than that of QA-I and QA-II sections. Lithostratigraphy and magnetic susceptibility of the sequence are consistent with the geomagnetic results. They show high similarity and correlativity with those of the QA-I and QA-II sections. These results confirm our earlier studies that loess deposition started in northern China by the early Miocene.

LOESS-PALEOSOL SEQUENCE,
 MAGNETOSTRATIGRAPHY, EOLIAN DEPOSITS,
 PALEOCLIMATE, MIOCENE

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Desertification in the semi-arid zone of China: Paleocological and ecological perspectives

Hongyan Liu

In the marginal area of Pacific monsoon influence in northern China, the annual mean precipitation varies from 200 to 400 mm, and the corresponding vegetation is semi-arid steppe. Desertification is the most severe ecological problems in this region and contributes to global environment through dust storms originated from the desertified land and transported to northeastern Asia and even across Pacific Ocean to North America. Desertification was regarded as land degradation in arid, semi-arid and dry sub-humid areas, resulting from various factors, including climatic variation and human activities. Most of the research works concerned realized that the interaction between nature and human factors caused desertification in China; however, they did not indicate the main contributing influence at different time period. Since over-cultivation and over-grazing are very common in the semi-arid region of China, large amount of works based on site observations usually underestimated the impact from nature factors and stressed that from human factors. In our study, both ecological and paleocological evidence was adopted to reveal the processes and mechanism of desertification during the Holocene in semi-arid northern China. It was demonstrated that vegetation cover decreased and deciduous forest and then pine forest retreated from the current semi-arid steppe region with climate becoming dryer since about 5900 yr BP. However, the most severe desertified area is the agriculture-pasture transitional zone, as interpreted from satellite imagery. This might imply that aridity change is most critical in vegetation development regionally and anthropogenic factors affect desertification only on a local scale.

DESERTIFICATION, STEPPE, HOLOCENE, NORTHERN CHINA, MONSOON OSCILLATION

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Sedimentological structure and timing of hiatuses in stalagmites and their climatic importance

Yu Liu, Yushi Lin, Meiliang Zhang, Jiaming Qin

Here, we use the D3 and D4 stalagmites of Dongge Cave in Guizhou, China, as an example to study the configuration of hiatuses in speleothems, i.e., their structure and timing, and their relation to climate change. The causes, age and duration of the depositional interruptions are discussed on the basis of traditional sedimentological analysis and TIMS dating. The D3 stalagmite ranges from 162.3 kyr BP to 91.0 kyr BP and the D4 stalagmite from 147.6 kyr BP to 0.128 kyr BP. The age of onset and duration of the interruption were determined for hiatuses in different climatic settings, such as the 27.9 kyr long hiatus of D4 stalagmite between 43.3 and 15.4 kyr BP, the 708 year depositional interruption between 4136 and 3991 yr BP, and the 23 year long interruption between 420 and 397 yr BP. The interface between calcite deposited before and after the depositional interruptions can reflect the cave deposit environment, geological events, and changes in regional climate, especially the onset of dry and cold periods. Therefore, the further and systemic study of the structure of hiatuses can provide complementary information to the study of rapid climate change and on the accurate characterization of abrupt events.

STALAGMITE, SEDIMENT INTERRUPTION, MULTILEVEL, CLIMATE IMPORTANCE

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Phytoliths as quantitative indicators for the reconstruction of past environmental conditions in China: Phytolith-based transfer functions

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We investigated the distribution of phytolith assemblages from surface soil samples at 243 sites along significant ecological and climatic gradients in China to develop transfer functions for quantitative reconstruction of paleo-environment. Canonical correspondence analysis (CCA) and detrended correspondence analysis (DCA) were used to determine the main environmental variables influencing phytolith distributions in the study area. The results reveal that mean annual precipitation (MAP) is the dominant variable controlling the spatial

distribution of phytolith, which explains 39% of the total variance. Mean annual temperature (MAT), relative humidity (Humi), and annual evaporation (VAP) are another three significant variables, explaining 6%, 10%, and 5% of the total variance in the phytolith distributions, respectively. Transfer functions, based on WA-PLS (weighted averaging plus partial least squares), were developed for MAP (R²-boot = 0.90, root-mean-square-error of prediction (RMSEP) = 148 mm), MAT (R²-boot = 0.84, RMSEP = 2.52°C), Humi (R²-boot = 0.75, RMSEP = 6.36%), and VAP (R²-boot = 0.59, RMSEP = 327 mm). Overall, our results confirm that phytoliths can provide reliable and robust estimates of MAP, MAT, Humi, and VAP. Thus, WA-PLS is a robust calibration method for quantitative paleoenvironmental reconstruction based on phytolith data.

PHYTOLITHS, QUANTITATIVE, INDICATORS, SOILS, CHINA

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Lagged response of the East Asian monsoon to insolation forcing, inferred from late Quaternary eolian activity in the Mu Us and Otindag sandlands (north China)

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Deserts and other drylands cover an area of around 1,000,000 square km in north and northwest China, including extensive dunefields and sand sheets. Vegetation cover and eolian activity in these drylands are highly sensitive to climate change. However, paleoclimatic change in these regions during the late Quaternary remains poorly understood, partly because of the scarcity of high quality age control. Here, 10 sites with eolian sand dune and sand/loess deposits in the Mu Us and Otindag sand lands in north China were sampled for optically stimulated luminescence (OSL) dating, and other measurements. The OSL age constraints and stratigraphic analysis, integrated with results of previous studies, suggest that the sand dunes were active in the last few hundred years, between 14 ka and about 7-8 ka, and between 50 ka and 60 ka. The sand dunes were mainly stable during the mid-Holocene, as indicated by the soil development that occurred between about 7-8 ka and 2.4 ka at multiple sites. Assuming that eolian activity is largely controlled by precipitation through its effects

on vegetation cover, these results imply a lag of several thousand years between peak of northern hemisphere summer insolation at 10-11 ka, and the peak of monsoon precipitation implied by dunefield stabilization after 7-8 ka. Although insolation may control monsoon variation over orbital timescales, millennial-scale change in monsoon strength may have other controls.

DUNEFIELDS, LATE QUATERNARY, EAST ASIAN MONSOON, INSOLATION FORCING, OPTICALLY STIMULATED LUMINESCENCE DATING

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Early human adaptation to the Tibetan Plateau

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We are currently investigating early human adaptation to the extreme environments of the Tibetan Plateau to aid in evaluating the initial occupation of Beringia and the Americas. Based on surveys of MIS 3 shorelines around lakes on the northeastern margin of the Plateau, together with test excavations of sites near Qinghai Lake and the central Kunlun Mountains, we hypothesize a three-step model for the "colonization" of the Plateau. The earliest 40-25 ¹⁴C ka sites are restricted to elevations below ~2500 m asl. Surface lithic scatters, dated to ~25-20 ¹⁴C ka both typologically and by their position on early MIS 3 shorelines overlooking shallower terminal MIS3 lakes, occupy mid-elevations locations ~2500-3500 m. Several small late Upper Paleolithic camps south of Qinghai Lake, characterized by simple hearths and limited cultural debris, are AMS dated ~12.5-11.0 ¹⁴C ka. Later forager encampments near Kunlun Pass and Qinghai Lake are radiometrically dated to the early Holocene. We suggest (1) an initial stage occupation of lower elevations, 40-25 ¹⁴C ka, by highly mobile foragers focused on the collection of high ranked resources, (2) a second stage dating to immediately prior and after the Last Glacial Maximum, 25-10 ¹⁴C ka, during which broad-spectrum foragers operating from more permanent home bases along the lower elevation margins of the plateau occupied temporary, short-term, special purpose foraging sites on the middle and upper steps of the Plateau, and (3) full-scale, year-round occupation of the

upper regions of the plateau by 10-6 ¹⁴C ka.

TIBETAN PLATEAU, HUMAN COLONIZATION, UPPER PALEOLITHIC, QINGHAI LAKE

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Future climate change impact perspective on the biogeochemical sustainability of the nutrient (CNP) flux through the Brahmaputra Basin

Chandan Mahanta

Strategic watersheds like the Brahmaputra reflect early signs of global climate change, being a biogeochemical hot spot located at transitional zones between different climatic regions and distinct ecosystems. The climate change impact on the colossal water (1.6 X 10¹² m³/y) and sediment (1.4 X 10⁹ tons; one of the highest in the world) injected from the Brahmaputra-Ganges during the southwest monsoon is a phenomenon of critical consequence. The thermal and dynamic influence of the snow-clad Tibetan Plateau plays a significant role in the evolution and formation of the Asian monsoon circulation, and affects climatic modulation of dissolved and particulate material fluxes through the Brahmaputra. It also impacts the relationship between spatial distribution of water and ecosystem diversity. As a result, basic characteristics of water circulation, especially geomorphologic influences on water movement and land-water-atmosphere interactions are severely affected. Here, we show that the Brahmaputra system carries almost 5% of the global particulate CNP input (computed as 6.3 x 10⁶ tons C/year, 8.5 x 10⁵ tons N/year, 8.4 x 10⁴ tons P/year). The open sea connection to this high nutrient flux is of particular importance, as time-series studies revealed sediment load fluctuations of an order of magnitude, indicating one of the highest variabilities. Due to intensified human impacts in the basin, results of the current investigations, though limited for such an understudied and hence less understood river, can point at indications that the future sustainability of CNP biogeochemistry of the entire basin is likely to be impacted significantly by the modified nutrient flux through the Brahmaputra.

BRAHMAPUTRA, CLIMATE, NUTRIENT, FLUX, BIOGEOCHEMISTRY

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Fluvial records from Gujarat alluvial plain and Kachchh, western India: Potential for decoding long-term monsoon variability during the last ~125 ka

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Late Quaternary fluvial sediment exposures comprise incised cliff sections of 35-40 m along the Mahi, Sabarmati, Orsang and Narmada river valleys in Gujarat alluvial plain and 15-25 m high cliffs along the rivers of southern Kachchh. Fluvial geomorphic mapping, stratigraphic study of over 50 sections and chronometric data of selected sections reveal the potential of reconstructing variability of the southwest Indian monsoon over the past ~125 ka. The base of the sequences in the Gujarat alluvial plain is marked by shallow marine origin (~125 ka) followed by vertically stacked fluvial sediments with intercalated paleosols. The occurrence of a buried paleosol in the fluvial sediments of Kachchh suggest their correlation with the upper part of the fairly complete fluvial record of the Gujarat alluvial plain. The exposed fluvial sequences in the various river valleys of Gujarat alluvial plain and coastal plain of Kachchh suggest contemporaneous deposition under a climatic regime that broadly followed global climate changes during the period. However, they show distinct differences in depositional styles and sedimentary architecture due varying nature of responses to the climatic fluctuations driven by the SW monsoon. The existence of more or less complete continental record of the last glacial cycle in a sensitive arid to semiarid climatic setting offers enormous scope for multidisciplinary paleoclimatic studies to delineate subtle variations in the SW Indian monsoon and correlate them with regional and global patterns of climate change.

FLUVIAL RECORDS, STRATIGRAPHY, PALEOCLIMATE, SW MONSOON, WESTERN INDIA

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Holocene monsoon variability as recorded in laminated and high-resolution sediment cores from the eastern Arabian Sea and its implications on forcing mechanisms

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High-resolution sediment records from the Arabian Sea margins provide ideal archives for deciphering long-term oscillations in Indian monsoons and possible implications on monsoon-triggering mechanisms. Proxy reconstructions were carried out on several well-dated, high-accumulation rate sediment records (sedimentation rate up to 1.83 mm/year) along the Oxygen Minimum Zone of the western continental margin of India. Temporal variations in the proxy

records of magnetic susceptibility, stable isotope, and inorganic and organic elemental concentrations suggest several abrupt events in monsoon precipitation during the early deglaciation (at ~16,000 yr BP) as well as during the early- to mid-Holocene. The early Holocene monsoon intensification occurred in two abrupt steps at 9500 and 9100 yr BP, and subsequently weakened in a step-wise mode, beginning at 8500 yr BP. A major weakening in precipitation is evident at ~7000 yr BP, synchronous with the Saharan aridification. This study also indicates a close relationship between monsoon precipitation and historical changes, with extremely rapid oscillations during the mid- to late-Holocene Indus Valley civilization periods. Our data reveal statistically significant periodicities at all millennial, centennial and multi-decadal bands that exist in the tree ring ¹⁴C data and/or other solar proxy records. Such a relationship authenticates an intricate but all pervasive influence of solar activity variations on the Indian summer monsoon over the entire spectrum of millennial, centennial and multi-decadal timescales during the Holocene.

HOLOCENE, MONSOON, ARABIAN SEA, SOLAR FORCING

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First >60,000-year annually resolved lacustrine record of East Asian Monsoon variability from NE-China

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Continuous sediment records of 39 and 24 m were recovered from the center of the two dimictic maar lakes Sihailongwan (SHL) and Erlongwan (ERL), respectively, which belong to the Quaternary Long Gang Volcanic Field (Jilin Province, NE-China). The chronology of the Lake SHL sediment record is based on varve counting and AMS ¹⁴C-dating of terrestrial plant remains. Detailed hydro- and geochemical studies imply that the photosynthetic production in Lake SHL is mainly controlled by nutrient influx via groundwater inflow. Presuming that groundwater inflow largely depends on summer monsoon rainfall, variations in the summer monsoon strength can be reconstructed by estimation of productivity-indices as biogenic silica. The siliciclastic sediment fraction of the Holocene SHL sediments largely originates from eolian input of remote provenance. Eolian influx is quantified and characterized by its geochemical and mineralogical

composition. Seasonal silt layers, probably related to dry deposition of dust in early spring, are clearly identifiable in thin sections. Thickness analyses of these seasonal silt layers, in combination with Micro-XRF analyses, will be used to reconstruct inter-annual variations in dust influx during spring. Palynological data, geochemical sediment composition, $\delta^{13}\text{C}$ data of the organic sediment fraction, bulk sediment $\delta^{15}\text{N}$ data, and seasonal varve structure reflect millennial-scale climatic fluctuations during the Last Glacial, a much expressed Younger Dryas-like climatic deterioration, and comparably lower climatic variability during the Holocene. Detailed rock- and paleomagnetic investigations allow an inter-lake correlation between Lake SHL and Lake ERL and support the varve- and ^{14}C -age based chronology of the lake sediments.

EAST ASIAN MONSOON, LAKE SEDIMENTS, VARVES, DUST, PALEOLIMNOLOGY

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Ostracod-inferred lake evolution in northwestern Inner Mongolia during the last 2500 years

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Two sequences from Lake Sogo Nur (Western Juyanze) in Inner Mongolia provide a detailed record of changes of the lake ecosystem during the last ~2500 years. According to the ostracod assemblages of both sections, Lake Sogo Nur has been a perennial lake with a relatively low albeit fluctuating salinity (less than 10‰) during

most of this period. It was not before the 1960s that the lake turned into a temporary water body resulting from extensive withdrawal of water for irrigation purposes in the Hexi Corridor (Gansu Province). Several lake-level and salinity phases were reconstructed: (a) intermediate lake levels prevailed between ~2500 and 1900 cal yr BP, (b) a rapid drop in lake level led to shallow conditions at ~1700 cal yr BP, (c) followed by a lake-level rise at ~1400 cal yr BP and high levels until ~700 cal yr BP, and (d) decreasing levels and the establishment of sub-littoral conditions afterwards. The water level of Lake Sogo Nur was probably controlled to some extent by the fluctuating population density in the catchment area and by the prevailing type of land use (agriculture versus stock breeding) although the low number of dated horizons (2 per sequence) prevents from a firm correlation of the lake's history with human activities in the region. The comparison of the results of our study with environmental and climate reconstructions from other sites may help to resolve, whether human impact and/or climate was the main driving force of the hydrological balance of Lake Sogo Nur.

NW CHINA, LATE HOLOCENE, OSTRACODA, SALINITY RECONSTRUCTION

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Compound-specific hydrogen isotope ratios of n-alkanes: A novel tool to reconstruct paleohydrology and paleoclimate on the Tibetan Plateau

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Compound-specific hydrogen isotope ratios on sedimentary biomarkers (n-alkanes) that record the organisms' source water δD value were measured from sediments of Lake Nam Co (Central Tibetan Plateau) to provide information on water balance fluctuations. Biomarker identification reveals long-chain n-C29 and n-C31 alkanes originating from leaf waxes of land plants within the sediments and as well as n-C17, n-C21 and n-C25 alkanes synthesized from algae and submerged aquatic plants. Assuming monsoonal precipitation as the water source for lake surrounding land plants, the measured isotopic composition of the corresponding sedimentary n-alkanes results in a fractionation ($\epsilon_{29-31/w}$) of -120 to -141‰ being consistent with mean ϵ_{water} values of -130‰ for long-chain n-alkanes from European lake sediments. Using the constant $\epsilon_{21-23/w}$ of -157‰ for the aquatic n-alkanes a lake water δD value of -20‰ is reconstructed. This is about 60‰ heavier than the measured lake water δD value and even 80‰ heavier than the meteoric water at Nam Co. This discrepancy may be attributed to an increase in summer monsoon

precipitation in conjunction with decreased lake evaporation. Furthermore evaporation processes inside the Nam Co lake system cause an enrichment in the aquatic derived n-alkanes relative to that of terrestrial origin of ~50%. This may serve to reconstruct two different isotopic signals directly: δD of precipitation and lake water δD . Those can be quantitatively compared to general circulation modeling studies, focusing on the effects of changed precipitation and evaporation rates on the isotopic signature to combine data and model interpretation to infer variations in monsoonal activity during the Holocene.

PALEOCLIMATE, COMPOUND-SPECIFIC δD , TIBETAN PLATEAU, EVAPORATION, MODEL

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Weather information in and around Hexi Corridor in the period of the Qing Dynasty described in official documents preserved at the First Historical Archives of China

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For reconstructing past climate, analyses of such proxies as tree-ring, ice cores, sediment cores have been carried out intensively. Time resolution of those data from the proxies is normally decadal, annual, and seasonal even at the best case. Also, the special resolution is not enough to reconstruct past weather, since number of sampling sites is not sufficient in many cases. The First Historical Archives of China have preserved enormous amount of official documents written in the period of Qing Dynasty. They include daily data of the amount of rain and snow from 1707 to 1911, for more than 200 years, which we have found in copies of memorials with additional data attached. We have chosen the documents sent from local observation sites in and around Hexi Corridor, roughly Gansu Province at present, where more than 80 observation sites have been identified. Those data can be used to reconstruct the weather over the area in the period.

QING DYNASTY, SNOW AND RAIN DATA, FIRST HISTORICAL ARCHIVES OF CHINA, HEXI CORRIDOR, DOCUMENT

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Pollen-based reconstruction of vegetation in China during the mid-Holocene and Last Glacial Maximum using a global scheme of plant functional types

Jian Ni, Ge Yu, Sandy P. Harrison, I. Colin Prentice

A total of 806 pollen surface samples, 188 mid-Holocene (MH) and 50 last glacial maximum (LGM) pollen records were used to reconstruct vegetation patterns in China, based on a new global classification of plant functional types and a standard numerical technique for biome assignment (biomization). The biome reconstruction based on pollen surface samples showed convincing agreement with present potential natural vegetation. Coherent patterns of change in biome distribution between MH, LGM and present are observed. In the MH, cold and cool-temperate evergreen needle-leaved forests and mixed forests, temperate deciduous broad-leaved forest, and warm-temperate evergreen broad-leaved and mixed forest in eastern China were shifted northward by 200-500 km. Cold deciduous forest in northeastern China was replaced by cold evergreen needle-leaved forest while in central northern China, cold deciduous forest was present at some sites now occupied by steppe and desert. The forest-steppe boundary was 200-300 km west of its present position. Temperate xerophytic shrubland, steppe and desert covered a large area on the Tibetan Plateau, but the area of tundra was reduced. Treeline was 300-500 m higher than present in Tibet. During the LGM, in contrast, cold deciduous forest, cool-temperate evergreen needle-leaved forest, cool mixed forests, warm-temperate evergreen broad-leaved and mixed forest in eastern China were displaced to the south by 300-1000 km, while temperate deciduous broad-leaved forest, pure warm-temperate evergreen forest, tropical semi-evergreen and evergreen forests were apparently absent from the mainland of southern China. Strong shifts of temperate xerophytic shrubland, steppe and desert to south and east occurred in northern and western China and on the Tibetan Plateau.

BIOMIZATION, POLLEN, PALEOVEGETATION, MID-HOLOCENE, LAST GLACIAL MAXIMUM

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Groundwater discharge and nutrient flux into the coastal Arabian Sea

Joseph Paimpillil, Thresiamma Joseph, Balachandran Krishnan

In constructing water budget and mass flux estimations for coastal margins, submarine groundwater discharge is often overlooked. The groundwater discharge can be substantial and can influence oceanic chemistry through discharges of nutrients from fertilizers and trace metals from the weathering of the aquifer protoliths. Recent investigations in coastal Arabian Sea have shown sufficient indication of groundwater seepage to sea through the narrow strip of submerged porous lime shell beds running almost parallel to the coastline. This flow seems to be seasonal but supplies considerable quantities of primary nutrients to the coastal waters and preconditions it for rich primary production. This study reveals the highest value for chlorophyll *a*, approx. 3 times greater than the peak values reported so far from these waters. A band of N/P >15 funneling out from coastal pockets and low saline pockets provides indications of 'external sources' of nitrogenous compounds into the coastal waters. The necessary forcing for the groundwater flow is gained when the fresh water lake level and the sea level reach a critical value. Such conditions prevail during the peak southwest monsoon months due to heavy river discharges to the lake. The possibility of heavy rains and flash floods linked with cyclones are high with ongoing climate variability. Such critical conditions can occur during other seasons and also at similar locations in the coastal region.

GROUNDWATER, NUTRIENT FLUXES

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Holocene paleosol S_0 and its climatic significance in the Fenwei Basin, Northern China

Jiangli Pang

Loess paleosol sequences of the Chinese Loess Plateau are important records of late Pleistocene through Holocene climate change. The Holocene S_0 paleosol in the sequence has been studied limitedly. Our stratigraphic, micromorphological, and geochemical studies in the Fenwei Basin and the Nanjing region show that loess deposition and soil formation are correlation processes. The S_0 paleosol in the areas of the Xiashu loess distribution near Nanjing is identified to be Ferric Luvisol (Yellow Brown soil) formed under a wet, warm subtropical condition in the mid-Holocene.

In contrast, in the Fenwei Basin, there was also a wet, warm subtropical climate formation in the Middle Holocene, the S_0 paleosol is a Luvisol (Cinnamon soil). The difference in the soil type was caused by the greater eolian dust inputs in the Fenwei basin during the soil formation.

SOIL, HOLOCENE, LOESS PLATEAU, CHINA

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Origin and deposit environment of the late Miocene-Pliocene Red Clay in the Chinese Loess Plateau—biological evidence from terrestrial mollusk fossil record

Yunpeng Pei, Naiqin Wu

The origin and sedimentary environment of the late Miocene-Pliocene Red Clay Formation in northern China has long been controversial. A new mollusk record from the Xifeng Red Clay (red-earth) sequence in the central Loess Plateau provides the biological evidence for addressing questions of its origin and environmental implication. The study of composition and preservation condition of 70 mollusk fossil assemblages reveals initial ecological condition of the red clay formation, avoiding the effect of post-deposited alteration. The result shows that all of the identifiable mollusk species are composed of terrestrial taxa, most of them are common species found in the overlying Quaternary loess-paleosol sequence. Most of the fossil individuals preserved in the red clay strata are in living condition based on the investigation of fieldwork, indicating the original population. Thus, the mollusk fossil assemblages can be used as an indicator of primary environment of the red clay formation. The mollusk record from the Xifeng red clay sequence supports the view that the red clay is of eolian origin, similar to the overlying Quaternary loess deposits. Our data also reveal the history of environmental changes at Xifeng from 6.2-2.4 Ma, which is coupled in phase with the formation and development of the Arctic ice sheets and the process of the Tibetan Plateau uplift. Both may be the major cause and forcing mechanisms of late Tertiary environmental changes in the Loess Plateau.

MOLLUSK FOSSILS, RED CLAY, LATE MIOCENE-PLIOCENE, ENVIRONMENTAL CHANGES

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Clay mineral assemblages of the Hipparion Red-Earth Formation in the Chinese Loess Plateau and its environmental implications

Shuzhen Peng, Zhengtang Guo, Qingzhen Hao

Earlier studies on typical Hipparion Red-Earth Formation, also referred to as "Red Clay" deposits indicate that a major part of it is of wind-blown origin, covering the period from ~7-8 to ~2.6 Ma. Therefore, it has great potential for the study of climatic history of the Loess Plateau region. An attempt has been made to explore the environmental evolution during the late Miocene-Pliocene by means of the composition and structure of clay minerals. Major components of clay minerals in the Hipparion red-earth formation at Xifeng section, calculated by comparing major peak areas, were estimated as illite (55-80%), kaolinite (7-20%), chlorite (4-13%), and smectite (2-23%), which shows similar components as Quaternary loess-paleosols. According to the general zonal distribution of soil clay minerals, clay mineral assemblages of Hipparion Red-Earth Formation in Xifeng sections indicate a typical climate fluctuating between temperature-humid and warm-sub-arid. Illite in the Hipparion Red-Earth Formation has better crystallinity (poorer value of the FWHM) than that in Quaternary loess, which indicates that Asian summer monsoon system was stronger during the late Miocene-Pliocene than in Quaternary. The Asian summer monsoon became weaker from ~4 Ma, and two major steps are observed at 3.6 and 2.6 Ma, respectively. We think that Tibetan uplift and ice-building processes in the northern hemisphere were two prominent driving forces for the long-term summer monsoon in Loess Plateau during Late Miocene and Pliocene times.

CLAY MINERAL ASSEMBLAGES, HIPPARION RED-EARTH FORMATION, EAST-ASIAN SUMMER MONSOON, TIBETAN UPLIFT, ICE VOLUME

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Tectonics and paleoclimate in Quaternary paleolake deposits in Ladakh, NW Himalayas

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All through Quaternary times, the Tethyan Himalayan segment has been subjected to neotectonic movements that have not only given rise to its structural design but also shaped its geomorphology. The Quaternary paleolake deposit segment of NW Ladakh, India, lying between the Karakorum Fault, the Indus Suture Zone was studied. Two large lakes (Spituk-Leh about 35-40

km in length, along the Indus River, and Khalsar Lake about 80 km in length along the Shyok River Valley) existed ca. 60 ka BP and ~30 ka BP, respectively, and were formed tectonically. Later, due to the revival of tectonic activities, they drained out leaving behind their sedimentary record, which was put under investigation for environmental/mineral magnetic, geochemical, sedimentological and clay mineralogical parameters. These are being inferred in terms of paleoclimate and tectonic activity in the Tethys Himalaya, during late Quaternary times. Covering a time span from >60 ka BP to ~20 ka BP (dates of different sections), the sections show fluctuations of warm and humid and dry spells of climate. The data generated to date reveals that stable lake conditions and warm climatic conditions prevailed between ~50-45 ka BP and 33-30 ka BP. Paleoseismicity is also recorded at ~26, 24 and 21 ka BP in the area. Our aim is to record dynamic changes in the sediment development process and paleoclimate, suitable for high-resolution stratigraphic correlation and reconstruction of climate change during the late Quaternary in the Ladakh Tethyan Himalayan segment.

QUATERNARY, PALEOCLIMATE, LADAKH, TECTONICS, PALEOLAKE

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Land-sea correlation of eolian dust records from the Chinese Loess Plateau and the Western Pacific Marginal Seas

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The formation, transport and deposition of eolian dust are intimately coupled to and indicative of changes in paleoclimate. Several physico-chemical properties of dust can be used to trace the source area and to characterize the mode of transport. Many geological investigations in the loess covered region of central China have used grain-size measurements as a basis for differentiating widespread loess and paleosol units, correlating them regionally, and relating them to the deep-sea isotope stratigraphy. Another important paleoclimate archive, potentially containing an undisturbed eolian dust record, is represented by the hemipelagic mud deposits in the marginal seas of China and Japan. The present contribution provides a synthesis of the grain-size results obtained for a series of loess-paleosol sequences from the Central Loess Plateau core, and of two marine sediment cores obtained from the South China Sea and Japan Sea. The aim is to decompose the grain-size distributions into a set of sedimentary components ('end

members') with the end-member modeling algorithm EMMA, and to relate the spatio-temporal changes in their proportional contributions to different sediment supply patterns and ultimately to climate changes. The modeling results clearly suggest that the studied sediments are adequately described as mixtures of a series of sedimentary components which are related to eolian dust, fluvial/hemipelagic mud, volcanic ash input and to sediment reworking processes. The ultimate aim of our project is to compare and to correlate the terrestrial and marine dust records and thereby directly linking the Asian monsoon histories of both land and sea.

EOLIAN DUST, LOESS PLATEAU, SOUTH CHINA SEA, JAPAN SEA, GRAIN-SIZE DISTRIBUTION

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Lake level change and its environmental evolution at the end of Heihe River, Inner Mongolia, China

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The lake area at the end of Heihe River, Inner Mongolia, China, is one of the most sensitive place with response to the environmental change within the margin of Asian monsoon. On the northern slope of the Qilian Mountains, broad alluvial fans extend toward northernmost end of the Heihe drainage basin. There are Juyan terminal lakes such as Gashun, Sogo and Tian-e-hu lakes situated in desert environment from northwest to southeast. Recently those lakes were almost dried up excluding temporary supply of water. Tian-e-hu lake is a small lake situated in the northwestern end of Old Juyan lake that has been dried up in the historical time. Based on the AMS dating of old gravel bars, lake deposits and core samples, and the analyses of pollen, ^{18}O of carbonate, ^{13}C of organic carbon and grain size for core samples, we reconstruct the process of lake level changes, climatic changes and vegetation succession in the region during the Holocene. We also explore the shift of rivers and lakes in the drainage basin, combined with distribution of historic archaeological relics.

TERMINAL LAKES OF HEIHE, HOLOCENE, LAKE LEVEL CHANGE, LAKE CORE, ENVIRONMENTAL EVOLUTION

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The loess record of the aerodynamic environment in the East Asia monsoon area since 60,000 years BP

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The interaction of wind, atmospheric turbulence and dust grain gravity along the dust transportation path results in a multimodal grain-size distribution for suspended dust. From a time series of paleo-atmospheric environments of the Loess Plateau, we find that there are three patterns of aerodynamic environments in the dust source area (stronger, strong, weak), and 13 strong turbulence events since 60,000 yr BP. During the last glacial period, the aerodynamic environment changed synchronously in the dust source and depositional areas over the entire trend. After 8,000 yr BP, the aerodynamic force is strong in the dust source area while the turbulence intensity is weak in the dust depositional area. The strong turbulence periods correspond to the cooling events such as the Heinrich events and the Younger Dryas cold event and may not be related to factors forcing the alternation between glacial and inter-glacial periods. Since 60,000 yr BP the three patterns of aerodynamic environments are mainly controlled by the environmental changes in the dust source area and may be related to fluctuations of the winter monsoon. In each pattern, fluctuations of the turbulence intensity in the dust depositional area and the distance from dust source to dust depositional area are the major changes of the environment. The summer monsoon, recorded by magnetic susceptibility, may vary prior to the winter monsoon since 50,000 yr BP. Changes in the intensity of the summer monsoon may force changes in the advance-retreat cycles of dust source areas in each winter monsoon pattern.

MULTIMODAL GRAIN-SIZE DISTRIBUTION, TURBULENCE AND AERODYNAMIC FORCE, LOESS AND PALEOSOL, WINTER AND SUMMER MONSOONS

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Climate change during Late Pleistocene and Holocene as recorded in fluvial and lacustrine sediments of a semi-arid alluvial plain, Western India

Rachna Raj

The exposed sediment records in the semi-arid river basins, lakes and ponds of an alluvial plain in Gujarat, Western India show diverse environments of deposition. These have been used to reconstruct the climate during the Late Pleistocene and Holocene. The fluvial facies are well developed in the river basins, whereas in the lakes and ponds these are overlain by thick lacustrine clay facies. Tidal clays overlie the fluvial sequences in the estuarine zone. The base of the exposed fluvial sequences have been dated to ~90 ka. There was a period of pedogenesis between 70 to 50 ka. Fluvial activity dominated again between 50 to 30 ka and the climate was predominantly semi-arid. The arid climate during the Last Glacial Maximum is represented by the stratified silts and sands. Early Holocene sediments are lacking, however, the Middle to Late Holocene is represented by estuarine sediments in the coastal areas and fluvial sediments in the upper reaches of the rivers. Early Holocene was a period of warm and humid climate that continued up to the Middle Holocene. The climate became drier during the Late Holocene. Palynological studies of the lacustrine clays indicate a restricted water, low salinity, paludal environment. Similar fluvial response to climate changes have also been reported from other parts of India.

CLIMATE CHANGE, FLUVIAL, SEA-LEVEL, PALEOENVIRONMENT, INDIA

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Solar forcing of quasi-200-year climatic variability in Central Asia: Evidence from *Juniperus turkestanica* tree-rings

Oleg Raspopov, Valentin Dergachev, Taneli Kolström

Tree-ring data of 800-year-old *Juniperus Turkestanica* collected at the altitudinal timberline of the Badakhshansky Mountain ridge in the Central Asia (39,50 N, 70,70 E) are analyzed. The revealed quasi-200-year variations in the radial growth of *Juniperus Turkestanica* have been found to correlate well (correlation coefficient is 0.77) with variations in solar activity (DeVries periodicity), 200-year temperature variations in the northern hemisphere during the last millennium, and also with quasi-200-year variations in climatic processes in Asia, Europe, and North and South America. The obtained results point to a pronounced influence of the DeVries periodicity of solar activity on global climatic processes. This work was supported by RFBR (projects 03-04-48769 and 03-05-65063),

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CLIMATE CHANGE, TREE-RINGS, CENTRAL ASIA

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Latest Pleistocene/Holocene environments and loess deposition at Heima He, southern Qinghai Lake, western China

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A 4-m section of Latest Pleistocene/Holocene loess and fluvial sediments was exposed during archaeological excavations at Heima He, on the southwest side of Qinghai Lake, Qinghai Province, western China. Analysis of the sediments includes magnetic susceptibility, carbonate content, and grain size. The sequence provides evidence for paleoenvironmental change associated with a record of human occupation in the Qinghai lake Basin. Radiocarbon dating of burned layers, augmented by OSL dates on eolian sands, provides a preliminary chronologic structure for the sequence. The base of the sequence contains fluvial deposits of a small low-intensity stream, similar to tributaries of the Heima He River today, which date to $11,040 \pm 70$ radiocarbon yr BP (13,384-12,717 cal BP). Fine grained eolian sands and silts overlying this basal fluvial deposit were locally deposited within a brief interval between about 13,500-12,500 cal BP. The cultural deposit is securely dated within this brief time frame. Above this cultural layer approx. 2 m of loess was deposited during the past 12,500 years, containing one major paleosol and several probable incipient paleosols. These paleosols can be linked to regional soil-forming episodes in the Qinghai Basin and far western Loess Plateau.

QINGHAI LAKE, LOESS, HEIMA HA, TIBETAN PLATEAU, PALEOENVIRONMENT

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SE Asian monsoon record from the mollusk assemblages in the Luochuan loess sequence during the past 470 kyr

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Chinese loess sequences are interpreted as a reliable record of the past SE Asian monsoon regime through the alternation of loess and paleosols units. Loess deposits are mostly related to winter monsoon whereas the soil complexes are interpreted as corresponding to summer monsoon. Different proxies have been used to describe this system, mostly geophysical, geochemical or sedimentological. Biological indices are very few and mostly limited to terrestrial mollusk assemblages. Using the present ecological requirements of the identified species allow to define two main mollusk groups, thermal-humidiphilous and cold-aridiphilous, characterizing summer and winter monsoon regimes respectively. The present investigation of the mollusk record in Luochuan is encompassing the S0-L5 series, which is about the last 470 kyr. Thermal-humidiphilous mollusks indicate a strengthened SE summer monsoon sensitive to obliquity and precession whereas cold-aridiphilous ones display a different pattern, with SE winter monsoon sensitive to obliquity and eccentricity periodicities. Finally, thermal-humidiphilous species indicate three particular patterns, during L2, L4 and L5 implying a strengthened summer monsoon during these three glacial intervals, a probable reply to particular astronomical configurations.

LOESS, PALEOSOLS, ASIAN MONSOON, MOLLUSKS, LUOCHUAN

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Variations in monsoon intensity and climate over the last 3,000 years triggered marked changes in a Himalayan peatland, India

Kathleen Rühland, Netajirao Phadtare, Rajendra Pant, Satish Sangode, John Smol

The Himalayan region of northern India is an important location for climatic studies on both global and regional scales as it lies within the Indian Ocean Monsoon (IOM) system. The glaciers common to the higher altitudes are amongst the oldest permanent ice fields on Earth whose melt waters together with monsoon rains provide life-sustaining resources

to one of the most densely populated areas in the world. Global warming, however, has accelerated glacier recession making their disappearance within the next few decades an alarming probability. In this region, long-term ecosystem changes are poorly documented. Here, we provide high-resolution diatom- and pollen-based evidence from a peat deposit that the last three millennia oscillated between wet and dry periods. In particular, a marked and synchronous shift commencing ca. AD 1790 in all of our proxies (diatoms, pollen, loss on ignition data, magnetic susceptibility) suggest an ecosystem turnover to a much wetter state, despite the fact that severe droughts have occurred during this period. We explore possible mechanisms for these proxy shifts including changes in monsoon intensity, accelerated glacier melting, and, in the more recent sediments, possible links to atmospheric pollution. Given the large population size that will be affected by environmental changes in this region and its vulnerability to climate fluctuations, these millennial to sub-centennial paleoecological records are of particular importance, as they provide context for natural variability at timescales required for understanding societal impacts.

HIMALAYA, PEAT, CLIMATIC CHANGE, DIATOMS, POLLEN

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Past-sediment discharge of large Asian rivers during the Holocene

Yoshiki Saito

Deltas are a principal coastal landform and important areas for human activities. In particular, large rivers form huge deltas characterized by wide delta plains along Asian coasts during the Holocene, which support large human populations. Asian deltas have evolved with strong influences by sea-level changes and human activities during the Holocene. Most Asian deltas were initiated 8000-9000 years ago, and huge deltas have formed especially during the last 6000-7000 years due to stable to slightly falling sea level. Sediment cores taken from Asian deltas show paleo-sedimentary environments and paleo-geography of deltas, and also past-sediment discharge of these large rivers in Asia. High-resolution core analyses have revealed that the Huanghe (Yellow River), Changjiang (Yangtze River), and Song Hong (Red River) have the significant increase of sediment

discharge on millennial timescale by human activities with related morpho-dynamical changes in deltas.

DELTA, SEDIMENT DISCHARGE, DEFORESTATION, ASIA, HUMAN ACTIVITY

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Reconstruction of glacier runoff using ice core data since the 1600s, northwest China

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The Qilian Mountains are located on the northern fringe of the Tibetan Plateau, Northwest China. There are glaciers in the mountains, since there is relatively high precipitation (more than 300 mm/yr) at high elevations. On the other hand, there is little precipitation (less than 50 mm/yr) downstream along the river. From ancient times, meltwater of glaciers and snow have provided drinking water and water for irrigation to the people living in those oasis cities. Therefore, the snow and glaciers on the mountain have been important water resources in this area. The purpose of this study, therefore, is to estimate the discharge from glaciers and the glacier mass balance using the ice core data based on the observed mass balance process. We estimated the fluctuation of precipitation and air temperature from the ice core data since the 1600s and meteorological data taken near the July 1st Glacier since the 1930s. Then, we calculated the mass balance and discharge. Calculated mass balance was in good agreement with the observed fluctuation of mass balance at the July 1st Glacier since 1975. The calculated fluctuation of mass balance since the 1600s indicated that the mass balance of the July 1st Glacier was at its maximum from 1750 to 1800. The discharge was large at the end of the 1800s and in recent decades. In the future, we will try to analyze multi-proxy data in order to reconstruct past climate conditions and will compare the fluctuation of discharge with extraordinary events written in historical documents.

GLACIER, MASS BALANCE, RUNOFF

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Fire and human impacts on vegetation changes during the last 10,000 years in Kyoto, Japan

Naoko Sasaki, Hikaru Takahara

Japanese forests have been heavily impacted by human activities. In adjacent areas of Kyoto, an ancient capital of Japan, the regional vegetation is mostly secondary forest, mainly composed of chestnut, deciduous oaks, hornbeams and red pine. This cultural landscape, so-called "satoyama", is believed to be the results of the long and continuous human activities, including the collection of fuel wood and litter for fertilization, slash and burn agriculture and partial logging. To reconstruct the history of fire and vegetation and to estimate when the "satoyama" was established in Kyoto and its adjacent areas, we obtained peat cores from three small basins (Mizoroga-ike, Jaga-ike and Hatchodaira), and analyzed fossil pollen, plant macrofossils and charcoal in the sediments. The cores cover over the last 10,000 years at all sites. The results from the three sites suggest that the "satoyama" was established at ca. 1500-1000 yr BP in the region. It coincides with the establishment of Kyoto as a Japanese capital 1200-years ago. Charcoal abundance increases conspicuously between 10,000 yr BP and 5000 yr BP at all sites. Charcoal records from several sites around Lake Biwa, east of Kyoto, also suggest that forest fires occurred frequently in the early Holocene. The causes of the frequent fires in the first half of the Holocene are still unclear, but the drier climate must have been partially responsible for the frequent fires either by anthropogenic or natural causes.

HUMAN IMPACT, FIRE AND VEGETATION HISTORY, CULTURAL LANDSCAPE, KYOTO, HOLOCENE

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Paleomonsoon and paleovegetation reconstruction during the Holocene in the Ganga Plain: Examples from Lahurdewa Lake

Anju Saxena, Indra Bir Singh, M.S. Chauhan, Vandana Prasad

Ganga Plain has a large number of ponds and lakes formed during the Late Pleistocene-Holocene. The lake-fill succession of Lahuradewa, Sant Kabir Nagar represents a time span of the last 10 ka. A 2.80 m thick lake-fill sequence has been studied to understand the paleomonsoon and paleovegetation changes during the Holocene. Multiproxy records in the form of lithology, $\delta^{13}\text{C}_{\text{org}}$, pollen spectrum, palynofacies, phytoliths, diatoms and clay mineralogy have been used to reconstruct changes in rainfall, paleovegetation, lake dynamics and anthropogenic activity. Human activity in the region is recorded in the form of microcharcoal since 10 ka. Cerelia and cultural pollens are present since 7 ka. Throughout the succession, grass pollens dominate

indicating a grass landscape with few thickets of trees. There are quantitative changes in the vegetation patterns in response to rainfall variation. Wild rice phytoliths are present since 10 ka. Cultivated rice phytoliths appear around 7 ka along with paddy field diatoms. Initially, the area was a moist swampy land leading to the formation of peat. Around 7 ka, the lake water body expanded and supported a rich aquatic flora along with some marshy taxa. The lake shows maximum development around 6-5 ka, followed by an increased rate of siltation and shrinkage of the lake water body. Late Holocene deposits exhibit some significant fluctuation in rainfall and paleovegetation. These results are similar to those occurring in other lakes of Ganga Plain, namely Sanai Tal. However there are specific regional differences. This study shows that Ganga Plain was a grassland throughout the Holocene with significant changes in the rainfall pattern.

PALEOMONSOON, PALEOVEGETATION, HOLOCENE, GANGA PLAIN, RICE CULTIVATION

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¹⁴C dating of lake sediments, variation in organic matter content and sedimentation rates in three diverse eco zones in the Indian subcontinent and their impact on lake succession and past climatic oscillations

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Sediment cores collected from three sites from diverse climatic zones in India namely Tsokar Lake, Ladakh, Jammu & Kashmir; Didwana Lake, Rajasthan, and Berijam Lake, Palni Hills, Tamil Nadu during the Late Quaternary have been used to provide information on variation in organic matter content and sedimentation rates. In Tsokar Lake, the rate of sedimentation is uniform with a value of 9.5 cm/100 years. The high rate of sedimentation shows the climate was primarily dry arid for the last 33 ka, because of which there was more melting of glaciers resulting in large deposition of sediment material into the lake. Large variation of organic matter content also suggests that the Tsokar Lake has undergone several successions from oligotrophy to eutrophy. ¹⁴C measurements from Didwana salt lake, Rajasthan at five intervals again reveal a uniform sedimentation rate of 3.9 cm/100 years. The low sedimentation rate shows that the landform conditions were primarily stable with dry arid climate during the last 8.1 ka period. The organic matter content shows several successions from oligotrophy

to eutrophy. ¹⁴C measurements from a 2.9 m sediment profile from Berijam Lake, reveal a rate of sedimentation of 2.9 cm/100 years. The low sedimentation rate reveals that the overall landform conditions were primarily stable during the last 17.7 ka. Large variation of organic content suggests that the lake has undergone several successions from oligotrophy to eutrophy. These results provide a means of considering the impact of potential future changes in landform conditions and climate in the study areas.

¹⁴C DATING, PAST CLIMATE, ORGANIC MATTER CONTENT, SEDIMENTATION RATE

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Tree-ring analysis of tropical Indian trees with special emphasis on *Tectona grandis* and *Cedrela toona*

Santosh Shah

Several tropical trees of India are known to produce growth rings. However, except for teak (*Tectona grandis*) and toon (*Cedrela toona*), the datability of these rings to the exact year of their formation—a prerequisite for tree-ring analyses—is yet to be established in these trees. Here, we explore the potential of tropical trees in dendroclimatic research, with emphasis on teak and toon. Teak has been analyzed from two sites of the peninsular region of India and has been determined to be more suitable for dendroclimatic analysis than toon. The latter has been studied from the Kalimpong subdivision, Eastern Himalaya. The teak chronology from Kerala extends from AD 1590-2000 (411 years) and Madhya Pradesh extends from AD 1836-1997 (162 years). This tree exhibits a positive relationship with precipitation and temperature during May, and June, and June and July, respectively, whereas there is a negative relationship with May and October temperature and March precipitation. A positive relationship with precipitation during May and June suggests that early SW monsoon precipitation plays an important role in the growth of teak. For toon, a 180-year (AD 1824-2003) ring-width chronology of this tree has been prepared. Tree ring data exhibit a positive relationship to precipitation during pre-monsoon months whereas August, September and October have a negative relationship. April and August have a positive relationship to temperature, February and March a negative one.

DENDROCLIMATOLOGY, TROPICAL TREES, TEAK, TOON, MONSOON

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Climate change and the history of China

David Sheu

Abrupt climate change accompanying prolonged droughts has been considered to play an important role in the collapse of human societies, including the Mayan, Egyptian and Persian civilizations. The dynastic change in the history of China is no exception to the correlation between climate change and societal turmoil. Here, I superimpose the date of the rise and fall of the Dynasties that are well documented in Chinese history on the reconstructed temperature trend in China during the last two millennia. The correlation between the dynastic changes and the temperature anomalies is astonishing. It shows that major dynastic changes, i.e., the Chou, Han, Tang, Song, Yuan, Ming and Ching Dynasties, all took place during the time when temperature plunged below average. The correlation also shows that short-lived dynasties, i.e., the Three Kingdoms, Wei, Jin, the South and North Dynasties, Sui (AD 221~617) and the Five Dynasties and Ten Kingdoms (AD 907~960), the most turbulent periods in Chinese history, all coincided with severe cold episodes, known previously as the Chinese Little Ice Ages (CLIA). Moreover, with no exceptions, all the major dynasties were overthrown by rebellions that were mostly farmers who fled their hometowns where large-scale famine occurred due to crop failure and shortage of food supplies. The entire history of China thus is a serial record of disastrous climate changes. If history is a lesson, a retrospect of Chinese history and the associated climate change should help shed light on the potential impact of future climate change on our human civilization as a whole.

CLIMATE, HISTORY, CHINA

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Paleoenvironmental changes in the Ganga Plain deduced from proxy records in lake fill sequences

Indra Bir Singh, Anju Saxena

A number of lakes and ponds are present in the central Ganga Plain containing sediment fill of the latest Pleistocene-Holocene age. Lake fill sequences, 2-3 m thick have been studied to reconstruct paleoenvironments for the last 20 ka using mineralogical-geochemical, pollen, micropaleontology and phytolith studies. These deposits show sand at the base, followed by marl-shell deposited (Early to Middle Holocene) in enlarged lakes. The top of the succession (Late Holocene) is made up of silty-muddy sediments. Formation of these lakes took place due to climate change, neotectonics and base level adjustments. Landforms during 20-13 ka were characterized by dense network of tributaries. 13-11.5 ka was a period of high rainfall and development of swampy areas. 11.5-10.5 ka was a period of reduced

rainfall and reduction in vegetation (Younger Dryas). 10.5-5 ka was a period of high rainfall and expansion of lakes. 5-3.5 ka was a period of reduced rainfall and siltation of lakes. 3.5 ka-present shows millennium-scale changes in rainfall with increased rainfall during 3.5-3 ka and 2-1.5 ka. The pollen studies show that the Ganga Plain was a grassland for at least the last 15 ka with few tree thickets. Anthropogenic activity is recorded for 15 ka in the form of micro-charcoal, cerealia and cultural pollens. Phytolith studies indicate wild rice growing since 10 ka and cultivated rice since 7 ka. The rainfall changes in the latest Pleistocene probably led to the early beginning of agriculture practices in Ganga Plain. The paleomonsoon changes in the Ganga Plain are related to the variation in the Bay of Bengal branch of the SW monsoon system.

PALEOMONSOON, LATE PLEISTOCENE, HOLOCENE, GANGA PLAIN, ANTHROPOGENIC ACTIVITY

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Phytoliths as indicators of monsoonal variability during Mid-Late Holocene in Mainland Gujarat, Western India

Vartika Singh, Vandana Prasad

Phytoliths—microscopic bodies of opaline silica produced in and between the vegetal cells—are now being increasingly used for the reconstruction of monsoonal fluctuations of dry regions. These phytolith studies were carried out on an 8 m profile of Mid-Late Holocene succession located at Itola, Dhadhar River Basin, which lies in the sub-humid belt, bordering the semiarid zones of Western India. The exposed sediment succession consists of interbedded sand, silts and clays with thin layers of terrigenous charcoal partings. The ^{14}C age of the basal most charcoal layer is 3620 ± 390 yr BP. The ratio of characteristic cool and arid to warm and humid grass phytolith associations have been used to reconstruct the monsoonal variation in this region. Our findings indicate that the SW monsoon gradually weakened during Mid Holocene while the winter monsoon, which is known to have commenced during Early Mid Holocene, was still persistent around 3620 yr BP, leading to cool climatic conditions. The later phase of this interval resulted in a climatic deterioration and development of dry and arid climatic conditions in this region. The dry and arid phase of a few hundred years of Late-Mid Holocene is followed by a period of wet and humid pulse of enhanced SW monsoon during Late Holocene, as evidenced by abundant warm season grass phytoliths, cultivated rice phytoliths along with paddy field indicator diatoms. Here, we also discuss the possible link between the rise and fall of the Harappan phase of the Indus Valley civilization and monsoonal

variability during Mid-Late Holocene in this area.

PHYTOLITH, MONSOON, MID-HOLOCENE, INDIA, GUJARAT

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Recharging paleochannels as a means for sustaining life in arid regions of Western India

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Major parts of Western India fall in arid to semi-arid hydroclimatic zones and suffer due to frequent drought. The dwindling water availability is not only fast eroding the coping capacity and economic potentiality of the people of this region but also severely impacting the bare survival needs of the people and livestock. A remote sensing study, supplemented by ground checks and a resistivity survey, has identified paleochannels in the semi-arid to arid regions of Rajasthan, India, which have very favorable geohydrological conditions and are amenable to recharging by rain water harvesting techniques, as well as imported water through canals, in a quite economically and environmentally friendly way. The recharge would not only further augment the ground water availability in the region, which may be used to mitigate the adverse impacts of the drought, but may also rejuvenate the lost river and ephemeral river system, leading to regeneration of the deranged ecological system. Here, the water prospect of paleochannels as well its recharging prospects by means of rainfall-runoff water as well as canal water are discussed. The study shows that paleochannels not only have potable quality of ground resource, which is manifested in the comparative yield of the wells, as well as chemical studies of the water samples, but the favorable hydrological conditions revealed by the resistivity survey points toward their being good rechargeable aquifers.

PALEOCHANNELS, AQUIFER, RECHARGE, SUSTAINABILITY

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Precipitation trends in the past 6,000 years from bulk geochemistry of lake and marine sediments, Luzon, Philippines

Fernando Siringan, Yvaine Sta. Maria-Yacat, Caroline Marie Jaraula, Zenon Richard Mateo

Changes in the XRF-derived bulk geochemistry of lake and marine sediments in cores are used to identify changes in precipitation patterns over the watersheds of Laguna Lake in southern Luzon and Lingayen Gulf in the northwestern part of central Luzon, Philippines during

the past 6,000 years. Age control is provided by ^{210}Pb , ^{137}Cs , and changes in bathymetry for the past 100 years and ^{14}C ages for the Holocene. Several paleoclimate indicators such as concentrations of Al and Ti, Al/Ti, and Chemical Index of Alteration (CIA) were correlated with instrumental rainfall data that extend back to the early 1900s. Al/Ti yielded the best correlation; an increase in rainfall corresponds to an elevation of Al/Ti, which might be due to greater delivery of fine-grained materials during wetter periods. Applied to the older sediments, Luzon appears to have been experiencing relatively dry conditions in the past 1400 years relative to the past few thousand years. The mountains of northwestern central Luzon, in recent years, appear to be wetter than southern Luzon and the past 1500 years. However, northwestern central Luzon seems to have had drier condition until 3000 years ago; southern Luzon was relatively dry until 4700 years ago. But the general trends for Luzon, of at least three wet and dry cycles during the past 6000 years, are consistent with other proposed precipitation changes in the region based on marine and terrestrial sediments.

PALEOPRECIPITATION, LUZON, PHILIPPINES, LINGAYEN GULF, LAGUNA LAKE

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Diatom community analyses in the core UN99-C1 from the Lake Ugii, Mongolia

Nergui Soninkhishig, J.A. Peck

Sources of past environmental change information are highly limited in Central Asia. Recent attention has been directed at Mongolia, however, as an excellent potential location for paleoenvironmental studies. Lake Ugii, central Mongolia, is a fresh water lake located in a dry steppe vegetation zone. In the summer of 1999, a 380 cm core was taken from the central basin at $47^{\circ}46'N$ and $102^{\circ}47'E$. Here, we present diatom distributional counts completed at 10 cm resolution. We identify 230 species, 26 of which are previously unknown in Mongolia. Variations in the relative abundances of the most dominant planktonic (*Aulocoseria granulata*) and benthic species (*Pseudostaurosira brevistriata*) in the down core distribution suggest environmental alteration. Comparison with known organic matter and carbonate mass fractions support this hypothesis. For example, an abrupt change in diatom species distribution occurs at a depth of 300 cm. At this depth, the sediment horizon is dominated only by *Anomooneis sphaerophora*, a diatom extremely resistant to fluctuations in the osmotic potential of its environment. Organics and

carbonates reach the lowest values of the record at this depth, suggesting high water levels. Similarly, plankton-benthos ratios correlate well with peaks in organics and carbonates at about 208-221, 285-293 and 349-357 cm depths. Low planktonic to benthic ratios and high peaks of organics could suggest low lake level and abundance of macrophytes and benthos along shallow shorelines.

DIATOMS, SEDIMENT, PALEOENVIRONMENT, CENTRAL MONGOLIA

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Late Quaternary vegetation history of NE-China: Recent progress in the palynological investigations of Sihailongwan maar lake

Martina Stebich, Jens Mingram

As part of an interdisciplinary investigation, paleobotanical studies are being undertaken on the maar lake Sihailongwan (Jilin Province) in order to reconstruct the vegetational history and climatic fluctuations recorded in the laminated lake sediments. The latest pollen diagram from Lake Sihailongwan represents the upper 15 m of the sediment sequence, at a sampling resolution of 10 cm. It illustrates the main vegetational features of the studied region during the last 25,000 years. The lowermost samples indicate steppe and open woodland communities, which are typical for glacial conditions. Moreover, the glacial pollen spectra show distinct fluctuations in *Picea*, *Larix* and *Artemisia*, which closely correlate with abrupt changes in varve thickness. This appears to provide indication of millennial-scale climatic fluctuations during the pleniglacial in NE-China. The climatic amelioration following the Glacial Maximum is reflected in the pollen record by a gradual increase in arboreal taxa. During this interval, *Ulmus* and *Fraxinus* begin to re-emerge in this region. The reappearance of *Picea* and *Larix*, coupled with a marked decrease of *Ulmus* and *Fraxinus*, immediately prior to the start of the Holocene implies intense cooling during a Younger Dryas-like period. The pollen diagram shows a predominance of deciduous forest during the Early Holocene, followed by an expansion in pine at about 6000 years ago. In this remote area, human impact signals are sparse and are restricted to the last 1100 years. It is expected that the successful completion of these continuing pollen analyses will provide a high-resolution paleobotanical record covering the last 60,000 years.

VEGETATION HISTORY, VARVED SEDIMENTS, NORTH-EASTERN CHINA

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Paleoenvironmental and paleoceanographic changes inferred from deep-sea sediments at the Korea Plateau, East Sea (Sea of Japan)

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Paleoenvironmental and paleoceanographic changes in the East Sea were investigated from the two piston core sediments collected at the Korea Plateau in the East Sea. The core sediments can be classified into 7 sedimentary facies, and the lowermost part was composed of the storm-influenced nearshore to shallow marine sediments of middle Miocene in age (12.8 to 13.4 Ma). The age dating of the sediments was carried out from the $^{87}\text{Sr}/^{86}\text{Sr}$ initial ratio (0.70881 to 0.70886), and this is the first report of the middle Miocene shallow water carbonates from the deep-sea sediments in the East Sea. The presence of these sediments implies that the Korea Plateau has been subsequently subsided into the present deep-sea position since the middle Miocene (the top of the Korea Plateau is deeper than 600 m). In core M04-PC1A, organic carbon and biogenic carbonate contents show big differences between the upper and lower part. Based on the C/N ratio of organic matter, the organic matter was supplied from the neighboring continent for the M04-PC1A core, whereas the organic matter from the M04-PC2 core (which is located at the central part of Ulleung Basin) was not supplied from the continent but from biogenic source. Oxygen isotopic records of the planktonic foraminifera (*N. pachyderma*) indicate that the pelagic sediments represent the Marine Isotope Stage 1 to 8 (~250 ka). Unlike the previously reported global paleoceanographic data, the oxygen isotope data during the glacial periods consistently show depleted signatures, indicative of surface-water freshening. This should result from the isolation of the East Sea basin due to the closure of the shallow straits around the East Sea during the Marine Isotope Stages (MIS) of 2.2 and 6.2. Also, the paleotemperature calculated from unsaturated alkenone index of the M04-PC1A core sediment were much lower (about 10°C) during the MIS 6 compared to the present-day temperature.

PALEOENVIRONMENT, PALEOCLIMATE, STABLE ISOTOPE, BIOMARKER, SEDIMENTARY FACIES

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Using fresh animal excrement to monitor heavy metal contamination in remote areas

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The concentrations of mercury (Hg), lead (Pb), copper (Cu) and zinc (Zn) were analyzed in excrements, feathers, bones and egg shells of seabirds and marine mammals collected from the Great Wall Station (63°23'S, 57°00'W), Zhongshan Station (69°22'S, 76°22'E) in Antarctica, Yellow River Station (78°55'N, 11°56'E) in Arctic and East Island (16°40'N, 112°44'E) in West Sand Islands of South China Sea respectively. By a comparison among the species, we found the scats of giant petrel and fur seal contain a higher Hg concentration than that of black-backed gull and Gentoo penguin for differences of trophic level, suggesting a bio-magnification up to the food chain. Geographical differences between similar trophic level seabirds were found for Hg and Pb in the excrements, briefly, the concentrations of Hg is the highest in West Sand Islands followed by Arctic and Antarctica due to the atmospheric contamination of Hg in the Southeast Asian for illegal amalgamative process to extract gold/silver, while the Pb level in Arctic is the highest followed by Antarctica then by West Sand Islands for the gasoline and industrial Pb emissions from the developed countries surrounding Arctic. The variations of Cu concentration in scat samples of above four sites indicate clearly their difference of geochemical background. While the changes of Zn level seem not to be indicative in these scat samples. In this study, the animal excrements show great advantages in monitoring the environment compared with other bio-monitors, due to their convenience to collect, easiness to measure and everyday refreshing, above all, the whole process of collecting does no harm to wild animals and could proceed under related laws and regulations. Therefore, we strongly recommend it be adopted as an ideal bio-material in those worldwide monitoring programs.

ANIMAL EXCREMENT, HEAVY METALS, BIO-MONITORING, POLAR REGION, SOUTH CHINA SEA

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Late Pliocene-Pleistocene changes in dust flux to the central Chinese Loess Plateau

Youbin Sun, Zhisheng An

Based on measured bulk density and refined astronomical timescale for two eolian sequences located in the central Chinese Loess Plateau (CLP), we estimated changes in the mass accumulation rate (MAR) of eolian dust in the CLP over the past 3600 kyr. Our estimated MAR demonstrates that since the late Pliocene, a trend towards more aridity has occurred in the Asian inland, while the humidity-aridity pattern has become more variable both in amplitude and in frequency from the late Pliocene to Pleistocene. Comparison of our MAR record with the MAR and $\delta^{18}\text{O}$ records from marine sediments suggest that the growth of northern hemisphere ice sheets over the last 3600 kyr may have play a part in increasing the Asian inland aridity, whilst phased uplift of the Himalaya-Tibetan Plateau and its effect on the East Asian monsoon variation may have profound influence on the shifts of the humidity-aridity variability of Asian inland since the late Pliocene. Correlation of dust records from ice cores, marine sediments and terrestrial loess over the last several glacial cycles suggest that glacial periods are characterized by higher and more variable dust flux than interglacial intervals. Furthermore, synchronous changes in the MAR, grain size and $\delta^{18}\text{O}$ records indicate a positive relation among the continental aridity, paleowinds intensity and ice volume change over the last several glacial cycles.

EOLIAN SEQUENCES, CHINESE LOESS PLATEAU, MASS ACCUMULATION RATE, ASIAN INLAND ARIDITY, LATE PLIOCENE AND PLEISTOCENE

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Deep-sea pollen research in the South China Sea

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Since the last decade, deep-sea pollen research has significantly progressed in the South China Sea. Based on sediment cores recovered during the "Sonne" cruise SO 95 and ODP Leg 184, a number of pollen sequences have been published covering the last 20 ka to 1 Ma. The high-resolution pollen records yielded a continuous history of vegetation, environment and monsoon evolution at centennial to millennial scales for the first time in this region. The pollen results have revealed a conspicuous contrast between the northern and southern shelves of the South China Sea (SCS) emerged during the LGM. The exposed northern continental shelf was covered by grassland vegetation mainly composed of *Artemisia*, indicative of a cold and dry climate as compared to the present day; while the

exposed Sunda Shelf in the southern SCS was covered by lowland rainforest, with mangroves along the coast and montane rainforest repeatedly migrated down the slopes. The climate there should be colder than it is today, but still was very humid and there was no indication of aridity. Judging from the pollen records, the winter monsoon was strengthened during the glacials, with a general enhancement since MIS 16. The summer monsoon was intensified during interglacials, particularly in MIS 15, 5 and 1. Spectrum analyses have revealed orbital and sub-orbital cyclicities in the vegetation changes. Cross spectrum analysis showed that the trend of vegetation changes in northern SCS was regulated mainly by ice volume in the northern Hemisphere, although signs of tropical forcing were also noticed.

POLLEN, DEEP SEA, SOUTH CHINA SEA, QUATERNARY

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Modern pollen spectra from surface peat bogs of the Nilgiris, Western Ghats

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We have analyzed the pollen content of 35 surface peat samples of the top 5 cm on a bog transect from three study sites Sandynallah, Bangitappal and Varahapallam from the Nilgiris (11°10'-11°30'N and 76°25'-77°00'E), a montane region (>1800 m asl) with complex topography and diverse climate-vegetation types. The natural vegetation is a mosaic of stunted montane evergreen forests with grasslands and many of the valleys feature peat deposits that are archives of the vegetational and climatic changes of the late Quaternary period. The aim of this study was to use pollen spectra of these surface peat samples as modern analogues to interpret the vegetation changes in the region due to natural or anthropogenic activity. The pollen counts from surface samples showed 114 different palynomorphs. Data analyses were carried out using percentage pollen diagram and multivariate statistics. Among the three sites, Sandynallah clustered separately, showed a lower diversity of pollen, perhaps due to disturbance from human settlements, and the absence of an evergreen forest patch close to the basin. Samples from Bangitappal and Varahapallam (higher rainfall compared to Sandynallah) showed similarity in species composition with more diverse pollen and forest elements indicating less disturbance at these sites. Such studies are useful in scaling down the global climatic models to regional focus by assessing the impact of disturbance, altitudinal and rainfall gradients that play a crucial role in natural succession of these fragile ecosystems, as in the case of Western Ghats. Part of this data has also been contributed to

the INDSUBIO biomization program, which aims at reconstructing accurate biomes in India.

MONTANE REGION, VEGETATION, SURFACE POLLEN, ANTHROPOGENIC PRESSURES, BIOME

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Vegetation history of the last 450,000 years for Kamiyoshi Basin, Kyoto, Japan, based on pollen from a long peat core dated by tephra layers

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A long core over 450,000 yr BP has been taken from Kamiyoshi Basin near Kyoto City in western Japan. This core contains continuous vegetation changes corresponding to the glacial-interglacial circles from the Marine Isotope Stage (MIS) 2 to MIS 12. The chronology was based on widespread tephra (AT: 29,000, Aso4: 87,000, K-Tz: 91,000, ASO-1: 249,000, Ng-1: 294,000 and Kkt: 334,000 yr BP, age of the tephra after Nagahashi et al. (2004)) and several AMS ¹⁴C dates. Here, we refer to the vegetation history from MIS 10 to MIS 2. During the period, in a glacial time, pinaceous conifer forests dominated by *Abies*, *Tsuga*, *Picea*, and *Pinus* subgenus *Haploxylon* developed. This vegetation was followed by cool-temperate deciduous broad-leaved forests composed mainly of *Fagus crenata*, *Quercus* subgenus *Lepidobalanus* and *Ostrya/Carpinus*. Also, in an interstadial and an interglacial time, forests were composed mainly of *Cryptomeria japonica* and *Sciadopitys verticillata* (umbrella pine) associated mainly with Cupressaceae trees. For the interglacial times, different types of vegetation were recognized each other. In the last interglacial, MIS 5e, forests were characterized by dominance of *Cryptomeria japonica* and evergreen oaks with *Abies*, *Tsuga*, and *Fagus*. Also, small amount of *Lagerstroemia* pollen were detected during the MIS 5e. Modern distribution of this genus is the subtropical zone from China to the southeastern islands of Japan. On the other hand, in the periods of MIS 7 and MIS 9, evergreen oaks were not main component in the forests.

GLACIAL-INTERGLACIAL CYCLES, VEGETATION HISTORY, MARINE ISOTOPE STAGE, POLLEN, TEPHRA

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NE monsoon in South India during the past 2 ka based on sediment succession of a rain-fed reservoir

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In India, little is known about the past performance of the NE Monsoon. Sediments from a NE monsoon-fed reservoir in South India (Parambu Kanmai, 10°06' N; 78°18' E) enabled reconstruction of the NE monsoon variability for the past 2 millennia. The historical evidence and satellite imagery indicate the reservoir and its catchment have not been significantly disturbed by human intervention. The alternation of distinctive bands of poorly sorted coarse sands (CS) and clayey coarse sands (CCS) are interpreted to reflect high rainfall events under conditions of low vegetation and periods of low but sustained rainfall with vegetation, respectively. Optical dating of quartz grains and radiocarbon ages indicates that the deposits preserve a record of past ~7 ka. The sediment record of past 1.6 ka is amplified and 5 CS and CCS horizons are seen. The instrumental record of the past 100 years shows a mean rainfall of 880 mm/yr. The sedimentation in the period <430 yr to present, is predominantly comprised of clayey coarse sand. This implies that the preceding episodes of sand accumulation occurred under more intense rainfall that was in excess of mean rainfall +2 σ events. A thick cross-stratified sand unit at 1,000 years implies an extended duration of higher rainfall/storm surge events. The timing of these events offers prospects of recording the performance of NE monsoon during globally recorded events, viz. the Little Ice Age and Medieval Warming. We will further elucidate the rainfall records based on results from environmental magnetism, chemical and palynological analysis.

NE MONSOON VARIABILITY, RAIN-FED RESERVOIR, DATING, LITTLE ICE AGE, MEDIEVAL WARM PERIOD

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The recent climatic warming revealed from stable isotopes in Muztagata ice core, eastern Pamirs

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Efforts have been made to clarify the climatic significance of stable isotopes in ice cores around the Tibetan Plateau through the study of present stable isotopes in precipitation. A new shallow ice core from Muztagata, eastern Pamirs, allows for a detailed comparison of annual $\delta^{18}\text{O}$ variation and local, even global air temperature variations. The 41.6 m ice core drilled at 7,010 m provides a record of about half a century. The annual fluctuations of $\delta^{18}\text{O}$ in this ice core are significantly consistent with the annual air temperature changes in a nearby meteorological station-Taxkorgon, with a regression coefficient of 0.67. The $\delta^{18}\text{O}$ record from this ice core shows a rapid warming trend since the 1980s, resulting from global warming since that period. Moreover, the rapid warming confirms the notion that high-elevation areas are particularly temperature-sensitive to global change.

MUZTAGATA ICE CORE, $\delta^{18}\text{O}$, CLIMATIC WARMING

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Palynological evidence for vegetation changes from the Red-Clay on the Chinese Loess Plateau and implications for climatic changes during late Miocene and Pliocene

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The Asian monsoon system is an important component of the global climate. The loess-paleosol deposits from the Chinese Loess Plateau provide an important archive of the evolution of the Asian monsoon and paleoenvironmental changes of East Asia. Recent stratigraphic, geochronological, geochemical and sedimentological studies of the late Cenozoic Red Clay, which conformably underlies the loess-paleosol

successions, have suggested that the bulk of the Red Clay is also wind-blown in origin. Although the study of carbon isotopes has got some information on vegetation changes from the Red Clay, the detailed vegetation history from pollen records is still not known. Here, the palynological study on Red Clay sediments of the late Miocene-Pliocene from the Xifeng Section on the Loess Plateau of central China yields new information on vegetation and climate change during 6.2 to 2.4 Ma. Our results show that the Loess Plateau was mainly steppe, indicating lasting dry climate conditions on the Loess Plateau during the late Miocene to Pliocene (~6.2 to 2.4 Ma). Three ecological zones could be recognized during that period: A zone (~6.2 to 5.8 Ma) with shrub steppe flora; B zone (~5.8 to 4.2 Ma) with wood-steppe, indicating a comparatively humid regional climate; C zone (~4.2 to 2.4 Ma) with steppe to sparse steppe. The vegetation changes are linked to the uplift of the Qinghai-Tibetan Plateau during the late Miocene and also coupled with the Arctic ice-sheet development.

PALYNOLOGY, RED-CLAY, LATE MIOCENE-PLIOCENE, LOESS PLATEAU

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Evolution and variability of the Asian monsoon system: Final report of SCOR/IMAGES Working Group 113 SEAMONS

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During the last three decades, scientific interest in the history of the Asian monsoon system has increased significantly, resulting in a number of drilling and coring cruises devoted to paleomonsoon studies, and in continuing studies of the Chinese Loess Plateau. Given the significant developments and advances in paleo-monsoon studies, SCOR/IMAGES Working Group 113 was established in 1998 to assess the current status and outstanding issues in this dynamic area of paleoclimate study. The SCOR-IMAGES Evolution of Asian MONsoon (SEAMONS) working group conducted three workshops and one symposium (1998-2002). Its final report published recently in QSR provides an overview of the current status of monsoon proxies, of past and current paleo-monsoon research on tectonic to interannual timescales with a primary focus on marine sediment records, and put forward recommendations for future research efforts. According to the Final Report, additional efforts are required to make further progress in two critical areas. 1) For proxy development and evaluation, concerted efforts are required at long-term sediment trap deployments in key monsoon-influenced regions as well as development of adequate and widely available core-top

databases. These are necessary to assess the impact of modern oceanographic and seafloor processes on potential monsoon proxies. 2) A sufficient geographic distribution of downcore records is needed to assess linkages among the two monsoon subsystems (Indian and East Asian) and their role in the context of extratropical climate change. These records should have high sedimentation rates, requiring substantial survey support to identify the most appropriate coring and drilling targets.

ASIAN MONSOON, EVOLUTION, VARIABILITY, SCOR, IMAGES

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Record of stalagmite and environment evolution from Chongqing Area since 32-15 ka BP

Li Wang, Jianli Wang, Licheng Shen, Xiao He, Yushi Lin, Meiliang Zhang

On the basis of thermal ionization mass spectrometry U series measurements, the ages of the stalagmite from Chongqing Jinfo Mountain Liangtianwan Cave range from 31.90 ± 0.20 - 15.21 ± 0.08 ka BP, which corresponds to MIS2 to the late MIS3. The influence of East Asian and Southwest Monsoon to this area has been discussed for the late part of the of last glaciation. The oxygen isotopic variability of the stalagmite reveals that the regional paleoclimate changes can be divided into several stages: during the first stage (32-31.44 ka BP), corresponding to the late MIS3, it was warm and dry. The $\delta^{18}\text{O}$ value generally is lower than the average, which implies a strong Southwest Monsoon. During the second stage (31.44-18.29 ka BP), the $\delta^{18}\text{O}$ value was higher than the average, and the climate was cold and dry. During the third stage (18.29-16.96 ka BP), the climate changed obviously and the East Asian and Southwest Monsoon was very strong. During the fourth stage (16.96-15.02 ka BP), the climate was very cold-dry. Generally speaking across the whole period (32-15 ka BP), the $\delta^{18}\text{O}$ value changed from lower to higher, and the temperature changed from higher to lower. Heinrich events 1,2,3 are recorded at 15.793 ka BP, 24.863 ka BP, 30.244 ka BP, respectively.

TIMS-U SERIES AGES, OXYGEN ISOTOPES,
PALEOCLIMATE CHANGE, CHONGQING JINFO
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Black carbon records in Chinese Loess Plateau over the last two glacial cycles and implications for paleofires

Xu Wang, P.A. Peng, Z.L. Ding

To study the temporal and spatial changes in paleofires over the Chinese Loess Plateau, black carbon concentrations were analyzed on the loess-paleosol samples from Lijiayuan, Lingtai and Weinan section along the north-south transect. Using the orbitally-tuned timescales of the sections, the black carbon mass sedimentation rates (BCMSR) were calculated. Results show that in the last two glacial cycles, the BCMSR values in glacial periods are 2-3 times higher than in interglacial periods, and the BCMSR variability has a relatively strong precession-associated 23 kyr period, suggesting that the glacial cold-dry climate conditions were apt to induce natural fires over the Loess Plateau. Comparison of the BCMSR records among the three loess sections demonstrates that natural fire occurrence was much more intensive and frequent in the northern Loess Plateau than in the southern part, coinciding with the previous conclusion that the northern Plateau has experienced a drier climate regime in both glacial and interglacial periods. The substantial increase in BCMSR of the upper paleosol (S_0) relative to the lower S_0 at Lingtai and Weinan indicates that human activities have exerted a significant influence on fire regimes in the middle and southern Loess Plateau during late Holocene due to the relatively intensive agricultural usage of land.

BLACK CARBON, CHINESE LOESS PLATEAU, LAST TWO GLACIAL CYCLES, PALEOFIRES, HUMAN ACTIVITIES

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Origin of the Red Earthy deposit at the Northeastern Tibetan Plateau (China) and its implication to regional desiccation since the middle Miocene

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The Red Earthy deposit at Xining, at the Northeastern Tibetan Plateau (China), was studied with respect to soil microstructure, grain size, major and trace chemical elements, and magnetostratigraphy. Field investigations indicate that the Red Earthy Deposit has similar structure with the typical Red Clay in the Chinese Loess Plateau. Grain-size analysis shows that particles of the Red Earthy deposit are very fine and nearly without a sand fraction ($>63 \mu\text{m}$) component. Thin-section observations show that the coarse fraction ($>10 \mu\text{m}$) mainly consists of quartz and feldspar. Micas, pyroxene, hornblende are also observed. This mineralogical composition of the coarse fraction is similar to that of the Quaternary loess. There is a good agreement of the major and trace (including REE) element chemistry between loess and the Red Earthy deposits. These evidences indicate a wind-blown origin of the Red Earthy deposit. The magneto-stratigraphy investigation shows that the Red Earthy sequence was formed 11.4 Ma BP. The Miocene eolian sequence at Qin'an was reported recently, but its distribution is unknown. Our result indicates that the Miocene eolian deposits had extended to the northeastern Tibetan Plateau at least since the middle Miocene. Changes of the proxy index show two important desiccation events took place around 10 Ma BP and 7-8 Ma BP, respectively. The paleoenvironmental change at around 10 Ma may be a global event.

RED EARTHY DEPOSIT, NORTHEAST TIBETAN PLATEAU, EOLIAN DEPOSIT, ARIDITY, ASIA

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Lack of exact correlation between paleoclimate and the magnetic susceptibility of loess-paleosol sequence at northeastern Qinghai-Tibetan Plateau

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Research on magnetic properties of the late Pleistocene loess/paleosol deposit at the northeastern Qinghai-Tibetan Plateau has been carried out. Multi-proxy magnetic investigation suggested that the principal carrier of magnetization is magnetite/maghemite in both of the loess and paleosol horizons. The variations of low field magnetic susceptibility in the loess-paleosol sequences are mostly attributed by changes in amount of these two minerals. Saturation isothermal remnant magnetization (SIRM), and frequency dependent susceptibility discloses relative enrichment of ultra-fine magnetite/maghemite grains in most paleosols rather than the loess units, suggests that the magnetite/maghemite is of pedogenesis origin. However, the low-field magnetic susceptibility is not always enhanced in paleosols in these loess-paleosol deposits. In some paleosol horizons, magnetic susceptibility is quite low so that there is no direct links between the magnetic susceptibility and the intensity of pedogenesis in paleosols at the Dongchuan section. Although the ultrafine magnetite/maghemite grains may be linked with the process of pedogenesis, but response of the magnetic minerals to pedogenesis is complex, therefore, we could not fully interpret the magnetic susceptibility of the loess-paleosol sequences as an indicator of paleoclimatic changes.

MINERAL MAGNETISM, LOESS-PALEOSOL, QINGHAI-TIBETAN PLATEAU, MAGNETIC SUSCEPTIBILITY

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Rapid aridification of southern Xinjiang, northwestern China, at the end of the 8th century: Geochemical and ostracod evidence from Lake Bosten

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Geochemical proxies and ostracod assemblages in a 7.2-m-long core taken from Lake Bosten (42°N, 87°E), southern Xinjiang were analyzed. An age model for the core was established based upon 31 ¹⁴C dating points. The abundance of Ostracoda tests was low during the

period of AD 200-750 (Jin – MiddleTang Dynasty) while the fauna was dominated by *Darwinula stevensoni* and *Cytherissa lacustris*, indicating a high lake level (water depth ~10-20 m). Meanwhile, the sediments contain carbonate detritus without any aragonite grains. The ¹³C values of organic matter in the bulk sediment were also high, indicative of the presence of C3 plants and humid condition in the area. Conditions changed rapidly during the second half of the 8th century. Ostracoda became very abundant and diverse. Shallow-water species *Candona neglecta* increased significantly, associated with other eurysaline species such as *Stenocypris* sp., *Cyprideis* sp., and an epiphytic dweller, *Cypridopsis vidua*. The assemblages suggest that the water depths were less than 5 m, and the depositional environment was enriched in reeds and became desiccated occasionally. The ¹³C of organic carbon shifted rapidly to heavy values, suggesting a major increase of C4 plants in the drainage basin. The content of authigenic acicular aragonite increased conspicuously, implying strong evaporation. All the three lines of evidence point to a rapid transition to arid condition in the end of the 8th century. Archeological artifacts (particularly coins) unearthed from the neighboring area suggest that such a rapid aridification might have caused the decline of the Silk Route.

ANCIENT CIVILIZATION, RAPID CLIMATIC CHANGE, CENTRAL ASIA, SILK ROUTE, OSTRACODA

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East Asian monsoonal variation recorded in the soda straw in a limestone cave (South Korea)

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Limestone caves in the Korean peninsula have been affected by monsoonal climatic changes (humid in summer and dry in winter), thus the speleothems in these caves should reflect the same climatic variations. Monsoonal climatic variations can be detected from the soda straw in the Seopdong Cave, which grew for five years (July 1999~July 2004). This soda straw is ca. 20 cm long, and this implies that the growth rate is 4 cm/yr. Excess ²¹⁰Pb variation coincides well with the amount of precipitation during its growth, and the values are high during the summers (rainy seasons) and low during the dry winters (dry seasons). This indicates that radioactive-decayed ²¹⁰Pb incorporated into rainwater reached the cave very rapidly because the transit time of rainwater into the cave was very short. δ¹⁸O and δ¹³C compositions of the soda straw are -8.6

~-7.7‰ and -7.8 ~-5.8‰, respectively. Carbon isotope contents are relatively more depleted from 2000 to 2001, and this was probably due to the lower amount of precipitation during this interval. It is believed that smaller rainfall is reflected by more depleted $\delta^{13}\text{C}$ values, because degassing rate of CO_2 decreases with decreasing rate of cave water supplied from overlying limestone. On the contrary, the periods of higher precipitation (1999, 2002~2004) show more enriched $\delta^{13}\text{C}$ values. The overall trend suggests that $\delta^{13}\text{C}$ of soda straw should be controlled by the degassing rate of CO_2 . Higher degassing rate can be confirmed by higher partial pressure of CO_2 (1500 ppm) of cave atmosphere during summer, and lower pressure (430 ppm) during winter.

MONSOON, PALEOCLIMATE, SODA STRAW, STABLE ISOTOPE, LIMESTONE CAVE

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Marked ecological shifts during 6.2- 2.4 Ma revealed by terrestrial mollusk record from the Chinese Red Clay deposits and implication for paleoclimatic evolution

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A new mollusk fossil record from the late Tertiary Xifeng Red Clay Sequence in central Loess Plateau, northern China, reveals the process of ecological environmental changes. Three remarked ecological shifts took place in mollusk assemblages from 6.2-2.4 Ma, focused at about 5.4, 4.5, and 3.4 Ma, which reflect the variations in the East Asian monsoon circulations. A dominant cold-aridophilous group revealed an extreme cold dry climate; a period of strengthened the East Asian winter monsoon during 6.2-5.4 Ma. A predominant thermo-humidophilous group occurred in the mollusk fossil assemblages from 5.4-4.5 Ma, indicating a strengthening of the East Asia summer monsoon circulation. The marked occurrence of meso-xerophilous taxa during 4.5-3.4 Ma implied a mild climatic condition prevailing. From 3.4 Ma, the cold-aridophilous species again became the dominance in the fossil assemblages, indicating the winter monsoons gradually intensifying toward the Quaternary glaciation. Climate changes in this region were stepwise cooling from 5.4-2.4 Ma with a 1 Ma variability. The cooling trend is in good agreement with a general global cooling trend during this period, as documented by marine $\delta^{18}\text{O}$ records. The formation and development of the northern hemisphere ice

sheets during the late Pliocene accelerated the climate deterioration toward the Quaternary glaciation. The history of environmental changes revealed by the Red Clay mollusk fossils is coupled in phase with the process of the Tibetan Plateau uplift, which may be the major cause and forcing mechanisms of the late Tertiary environmental changes in the Loess Plateau.

RED CLAY, LATE MIOCENE-PLIOCENE, MOLLUSK GROUPS, PALEOCLIMATIC EVOLUTION, CHINA

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Coherence between solar variability and the East Asian Monsoon during the past 7600 years

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AMS ^{14}C dating and grain-size analysis for Core PC-6, located in the middle of mud area on the inner shelf of East China Sea (ECS), is carried out. The core recorded the history of environment changes during postglacial transgression. The core's mud section above 450 cm is mainly carried by the ECS Winter Coastal Current (ECSWCC) with suspended mechanics since 7.6 ka BP. Two grain-size populations with the division at about 28 μm are inferred by using a mathematical method called "grain-size vs. standard deviation". The fine population (<28 μm) is considered as the product of the ECSWCC. Its content above 450 cm changes little and represents stable sedimentary environment in accord with the present. High-resolution proxy for the East Asian Winter Monsoon (EAWM) is established based on the suspended population' mean grain-size. Times of mean grain-size augmenting abruptly are inferred to be cold periods during recent 8 ka, which may result from the strengthening EAWM. A direct comparison between the sunspots change and the mean grain-size of suspended population is carried out. The good correlation between them suggests that one of the primary controls on centennial- to decadal-scale changes of the EAWM during this time is variations of the sun irradiance. Spectral analyses of the mean grain-size time series of Core PC-6 show statistically significant periodicities centre on 2463, 1368, 128, 106, 100, 88-91, 76-78, 70-72 years. They agree with the East Asian Summer Monsoon' cycles well, and both are in accord with the changes of the sun irradiance.

EAST ASIAN MONSOON, HOLOCENE, EAST CHINA SEA, GRAIN-SIZE, SOLAR IRRADIANCE

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Holocene temperature and precipitation changes over the monsoonal/arid transition reflected by inorganic and organic carbon concentrations of sediment cores from Daihai Lake, Inner Mongolia, North-central China

Jule Xiao

Two sediment cores recovered in the central part of Daihai Lake in north-central China were analyzed at 2- to 4-cm intervals for total inorganic and organic carbon (TIC and TOC) concentrations. AMS ^{14}C time series of the TIC and TOC records of Daihai Lake sediments uncovers a detailed history of changes in temperature and precipitation in north-central China during the last ca. 12,000 yr. The Holocene, an epoch of postglacial warmth, started ca. 11,500 cal yr BP when the temperature began to rise. Changes both in the TIC and in the TOC indicate that the Holocene Epoch can be subdivided into three stages: the Early Holocene (ca. 11,500-8000 cal yr BP), Middle Holocene (ca. 8000-3300 cal yr BP) and the Late Holocene (ca. 3300-0 cal yr BP). The climate was warm and dry during the Early Holocene, warm and wet during the Middle Holocene, and in the Late Holocene became cool and dry but displayed a relatively warmer and wetter interval between ca. 1700 and 1300 cal yr BP. The Holocene Climatic Optimum, defined as a postglacial episode of both megathermal and megahumid climate, might have occurred in north-central China between ca. 8000 and 3300 cal yr BP, as marked by high TIC and TOC values. However, during the Holocene Climatic Optimum, unstable TIC and TOC concentrations may indicate that the climate was variable and punctuated by cool and/or dry events.

DAIHAI LAKE, SEDIMENT CORES, CARBON,
 HOLOCENE

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Morphological analysis of phytoliths in the Palmae family and its environmental significance

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Phytolith analysis is becoming more and more important in the studies of paleoenvironment, paleoecology, environmental-archaeology, plant-taxonomy, and other subjects. Its potential ability for application research has been discovered gradually

based on the development of systematic work on phytolith morphology analysis from modern plants. Here, we focus on the morphology difference of phytoliths from 15 genera, 20 species of Palmae plants, which are distributed mostly in tropic and sub-tropic areas. Moreover, we compared the phytoliths from Palmae plants to those of *Strelitzia nicolai*, *Heliconia lathispatha*, and *Saraca dives*. The results of cluster analysis show that the morpho-types of phytoliths can be classified into five categories. Among them, three morpho-types including spherical-spinulose shape, jellyfish shape, and conical-hat shape are from Palmae. While phytoliths from *Strelitzia nicolai* and *Heliconia lathispatha* have been attributed to spherical-drape and shuttle shape, respectively. The *Saraca dives* has no phytoliths discovered. In this study, we summarized the size and morphological characteristic of five phytolith types that provides a base for further paleoenvironment research by using Palmae phytolith analysis.

PHYTOLITH, PALMAE, MORPHOLOGY,
 PALEOENVIRONMENT, PALEOECOLOGY

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Temperature as the controlling factor for the expansion of C4 Plants in the Chinese Loess Plateau

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The understanding of the underlying factors controlling evolution and expansion of C4 plants is important for predicting changes of the future ecosystem because of their great ecological and economic significance. Much works have been carried out to unravel the mechanisms of the C4 plants expansion. But the results are disappointed, the causes as separate as atmospheric CO_2 decline, temperature increase, and less precipitation all have been suggested. Our recent work shows the regional climate might exert a strong control on the relative abundance of C3 and C4 plants. In order to constrain the factor dominating the expansion of C4 plants in the Chinese Loess Plateau, the organic carbon isotope composition ($\delta^{13}\text{C}_{\text{org}}$) have been measured on the samples from loess-soil sequences deposited during the last 70 ka. The carbon isotopic composition of samples from dry and cold intervals of those sequences in both of the north to south of the plateau corresponding to MIS 2 and 4 shows there were few C4 plants, indicating that the temperature was too low to grow for C4 plants, while $\delta^{13}\text{C}_{\text{org}}$ values of the samples from the interval deposited during MIS

3 increases obviously from the north to the south in the Chinese Loess Plateau. The above evidence supports the previous conclusion that temperature is the major factor for the variations in C4 plant abundance in the Loess Plateau, and indicates that $\delta^{13}\text{C}_{\text{org}}$ of organic matter in the loess-paleosol sequences can be used as an indicator in temperature changes in the Loess Plateau.

TEMPERATURE, C4 PLANTS, $\delta^{13}\text{C}_{\text{org}}$, CHINESE LOESS PLATEAU

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A high-resolution paleoclimate record of the last 60,000 years in stalagmite from the Yamen Cave, Guizhou, China

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Yamen cave is 12 km N of Libo County, Guizhou Province, at an elevation of 570 m, 1000 m long. Stalagmite Y1 were collected the deep below the cave surface; Y1 is 300 cm long, 15 cm in diameter. Eight TIMS ^{230}Th date measurements are from Y1. Time range of Y1 is from 59,000 year BP to 7225 year BP. Oxygen isotope ratios of stalagmites characterize the changes of $\delta^{18}\text{O}$ values of precipitation and monsoon. The climate events with abrupt changes in $\delta^{18}\text{O}$ values, which can accurately identify 8200 event, YD, Glacial Termination I, LGM, H1-H5 events. The peaks and valleys in the $\delta^{18}\text{O}$ curve of the stalagmite coincide with those of the northern hemisphere insolation curve.

PALEOCLIMATE, STALAGMITES, YAMEN CAVE

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Climate change in western China during the last two millennia

Bao Yang

China-wide temperature composites covering the last 2000 years were established by combining multiple paleoclimate proxy records obtained from ice cores, tree rings, lake sediments and historical documents. Five periods of temperature variation can be identified: a warm stage in 0-AD 240, a cold interval between AD 240 and 800, a return to warm conditions from AD 800-1400, including the Medieval Warm Period between AD 800-1100, the cool Little Ice Age period between 1400-1920, and the present warm stage since 1920. In addition, temperatures varied from region to region across the plateau. A warm period from AD 800 to 1100 in the northeastern Tibetan Plateau was contemporaneous with cooling in the southern Tibetan Plateau, which experienced warming between AD 1150 and 1400. Large-scale trends in the temperature history from the northeastern Tibetan Plateau resemble those in eastern China more than the trends from the southern Plateau. Natural archives like ice cores, tree rings, river and lake sediments, lake terraces, paleosols but also historical documents show climate change in northwestern China was warm and wet during the Western and Eastern Han Dynasties (206 BC-AD 220). Established regional precipitation curves for the arid and semi-arid zones of northwestern China display 5 dry periods, each lasting about 50 years. During the last 500 years, the trends of precipitation change in the eastern arid region are basically consistent with those in the western and eastern regions of the semiarid zone, showing that each regional precipitation series contains stationary century-scale periodicities of about 120 years. Precipitation variations in the western arid region are unique, showing significant local patterns of rainfall variability.

LAST TWO MILLENNIA, WESTERN CHINA, CLIMATIC CHANGE, ENVIRONMENTAL CHANGE, INTEGRATED STUDY

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A 2000-year record of mercury and lead level and Asia-Pacific civilization in red-footed booby droppings of South China Sea

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Here, we present a 2000-year record of mercury and lead concentration and lead isotopic composition in red-footed booby droppings collected from East Island (16°39'N-16°41'N, 112°43'E-112°45'E) in West Sand Islands of South China Sea, and found the dramatic variations of mercury and lead concentration likely

associated with the Asia-Pacific civilizations, especially with those related metallurgical activities. Briefly, Hg levels are high during four episodes of extensive gold and silver mining activities: Tang Dynasty (AD 600-900), South-Song and Ming Dynasty (AD 1150- 1500), New World (AD 1600-1800) and Industrial Revolution (from AD 1840 to present), while the mercury concentrations decrease significantly during wartime in China around AD 1000 and the Independence War of South America (~AD 1800-1830) for depressing productivities of gold and silver. In the last century, the mercury concentrations increase sharply, indicating technological revolutions on mercury metallurgy could not keep mercury contamination within limits due to increasing emissions from other sources. This record is the same as that in Antarctic seal hairs located in high latitude of the southern hemisphere, which further proves these historical mercury emission events might have global effects due to long-range transport of gaseous mercury. For lead contamination, the increments of lead concentration coincide with historical booming periods of lead melting, and its peaks correspond to that of Hg concentration. The isotopic compositions of lead might be applied to identify the original source of lead contaminants. Briefly, before about AD 1800, the Chinese mainland appears to be the dominant source of lead contaminant with higher $^{208}\text{Pb}/^{207}\text{Pb}$ ratios of 2.46-2.49. However, from AD 1840 the industrial and gasoline lead from Japan and America seems to play a more important role for decreasing $^{208}\text{Pb}/^{207}\text{Pb}$ to 2.44-2.46, and $^{206}\text{Pb}/^{207}\text{Pb}$ from 1.171 to 1.161-1.162.

RED-FOOTED BOOBY DROPPINGS, LAKE SEDIMENT, MERCURY AND LEAD, SOUTH CHINA SEA, ASIA-PACIFIC CIVILIZATION

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Reticular red soils in South China and its implications for East-Asian monsoon

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The mid-Pleistocene reticular red soils at Xuancheng, Anhui Province and Baise, Guangxi Province are studied using soil micromorphology, mineralogical and chemical methods. The results indicate that the reticular red soils are complex paleosols and have experienced multistage climate fluctuations. There are three main stages during their formation. The first stage is the formation of homogeneous red soils, the second is the formation of white reticulate veins and the third

is climate fluctuations between cold and warm. White reticulate veins, which resulted from local iron-losing of homogeneous red soils, represent an extremely humid period in South China and indicate that the precipitation was plentiful all through the year in the vast area south of Yangtse River when they formed. This implies that summer monsoon was extremely strong and this area was probably influenced distinctly by summer monsoon all through the year then.

RETICULAR RED SOILS, MICROMORPHOLOGY, PALEOENVIRONMENT, MID-PLEISTOCENE

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Lake-sediment records of recent climate variability in northwest China's drylands

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In sub-humid to semi-arid regions, climate change has mainly involved variations in effective precipitation. Meteorological records reveal recent changes in effective precipitation in many dryland regions, but such records are too short to capture the full amplitude of natural variability necessary for predicating the future: natural archives must therefore be used. Multi-proxy reconstructions from paleolimnological records that have accurate and precise chronologies may show climatic variation on 100- to 1,000-year timescales. Lakes Sayin Wusu West, Sayin Wusu East, Baoretlegui and Lexiketu are small, oligosaline, inter-dune lakes located in the Badain Jaran Desert, Chinese Autonomous Region of Inner Mongolia. Multi-proxy paleolimnological reconstruction of the lakes are currently being carried out from four short (<1 m) sediment cores. Dating of these sediment cores has been conducted using ^{137}Cs and ^{210}Pb . Reconstructed proxies include: paleoecological (pollen, ostracods), geochemical (trace elements in ostracods and authigenic carbonate) and isotopes from carbonates. From this evidence, it appears that significant limnological changes have occurred over the recent past. The calcium carbonate content varies from high and variable values, caused by relatively saline water, at the bottom of the core, to low and stable values, showing wetter conditions in the central part. The top of the sequence has increasing carbonate concentrations, reflecting lower lake levels and drier conditions, which has implications for the Minchin Basin, a large agricultural region located to the southeast of the desert. Future work will include the collection of sediment cores and modern environmental data from other Badain Jaran lakes during June 2005.

BADAIN JARAN DESERT, PALEOLIMNOLOGY, MONSOON, CHINA

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High-precision TIMS U-series and AMS ¹⁴C dating of a coral reef lagoon sediment core from southern South China Sea and its environmental significance

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Accurate dating of coral reef lagoon sediments has been a long-term difficult problem, although lagoon profiles, usually with high deposition rates, have a great potential for high-resolution climate reconstruction. We report 26 high-precision TIMS U-series dates (for coral branches) and 5 AMS ¹⁴C dates (for foraminifera) for a 15.4-m-long lagoon core from Yongshu Reef, Nansha area, southern South China Sea (SCS). All the dates are in the correct depositional sequence, revealing a ~4,000-year continuous depositional history. The results indicate that the deposition rate varied in the range of 0.8 and 24.6 mm/yr, with an average of 3.85 mm/yr. This corresponds to an average net carbonate accumulation rate of 4,197 g CaCO₃/m²/yr. Two fast deposition periods, one from AD 103 to 305 and the other for the last 1000 years, are identified. Episodes of elevated depositions within the last 1000 years correlated well in timing with strong storm events identified from storm-relocated coral blocks in the area. The highest deposition rates in the 1800s may be related to the tsunamis generated by the 1833 Sumatran earthquake and the 1883 Krakatau eruption. Therefore they are ideal for high-resolution (decadal-scale) reconstruction of paleoclimate and sedimentary environment in tropical oceans.

CORAL REEF LAGOON SEDIMENTS, TIMS U-SERIES AGES, AMS ¹⁴C AGES, SEDIMENTATION RATE, STORMS

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Historical reconstruction of climate and human impacts on the lower Yangtze River, east China

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Co-funded by NSFC and the Royal Society, this project aims to reconstruct historical climate and human

impacts on terrestrial ecosystems from sedimentary records in the lower Yangtze River, east China. The main study area is the densely populated catchment of Hangbu River in central Anhui. Sedimentary cores covering different timescales were taken from Longhekou reservoir, Lake Chaohu, and the floodplains. We have completed many laboratory analyses on these cores, including AMS dating, particle size analysis, magnetic measurements, organic carbon/nitrogen determination, XRF geochemistry, pollen and phytoliths. Data from documentary records, land use, meteorological and hydrological records and satellite images have also been obtained. With these data, we can now reconstruct and analyse the environmental change within the catchment as a result of interacting natural and human factors. A long (16.5 m) floodplain core (ACN) close to the edge of the modern Lake Chaohu provides the long term catchment record, with AMS dating of the ~10 m section of lake sediments giving ages of ~8800-2200 BP. Principal components analysis of phytolith data suggests three relatively dry periods (5500-5000, 4500-4000 and 3000-2500 BP) since the middle Holocene. Pollen data reveals that the natural forest mainly consisted of *Quercus* and *Pinus*, with the first human disturbance recorded ~5600 BP. Another major change occurred about 4100 BP, when *Quercus* forest was largely replaced by Gramineae, probably as a result of the development of cultivated rice. Since 1800 BP, pollen data suggest continued declines in forest cover with progressive anthropogenic impacts (Project No. 40271107, 40411130070)

HUMAN ACTIVITY, ENVIRONMENTAL CHANGE, SEDIMENTARY RECORDS, EAST ASIA, LOWER YANGTZE RIVER

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Multiple sedimentary evidence for Holocene monsoon dynamics from Qaidam Basin on the northeastern Tibetan Plateau, China

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We present preliminary data from Keluke Lake, a freshwater (0.8 g/L) lake located in a dry desert climate in Qaidam Basin. The chronology of the 688-cm core (KL05-2) taken under 2.7 m water was tentatively controlled by two AMS dates on plant macrofossils (4780 ± 50 and 9270 ± 50 ^{14}C BP). Loss-on-ignition analysis indicates that organic matter ranges 4-10%, while carbonate content oscillates greatly between <20% and >70%. Most low carbonate intervals correspond with clay-rich, "soil-textured" sediments containing abundant plant remains and roots, likely deposited in very shallow water wetland environments during reduced monsoon precipitation. On the other hand, high carbonate intervals indicate relatively deep and open water environments. Pollen analysis supports this interpretation, indicating that dry periods are dominated by desert pollen types including Chenopodiaceae (60-80%), Ephedra and Tamaricaceae, while wet periods by Poaceae (20-40%; mostly Phragmites-type), Artemisia (~20%) and Chenopodiaceae (~35%). The Artemisia-to-Chenopodiaceae ratio, an index of relative steppe and desert plant dominance, is <0.1 during dry periods but 0.6-0.8 in wet periods. Oxygen isotope and trace elements of ostracode (*Limnocythere inopinata*) shells are being analyzed to provide additional evidence for changes in lake salinity and water balance. Wet-dry climate oscillations of great magnitude occurred mostly from 11,300 to 3000 cal BP, while climate appears to be generally moist during the last 3000 cal BP (with consistently high carbonates of 60-70%). Our results suggest the pervasive nature of Holocene climate variations and the strong moisture response in continental interior as mediated by East Asian summer monsoon dynamics.

HOLOCENE, EAST ASIAN MONSOON, LAKE-LEVEL CHANGE, POLLEN, OSTRACODA

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Holocene lake level changes of Zigetang Lake, Tibetan Plateau

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The Zigetang Lake is an inland closed lake, located in the central Tibetan Plateau and influenced by the Southwest Monsoon. Its expanding and shrinking may directly show the variation of the strength of the southwest monsoon because the water level changes rely closely on the balance of precipitation and evaporation in the catchment. The authigenic carbonate content in the sediments could serve as a sensitive indicator of lake expansion and shrinking processes. Carbonate concentration along with dissolved salt composition (chlorine and sulfate) may show the evolution stages of lake water chemistry. According to the analyses data of a laminated sediment core from the central Zigetang lake, a high-resolution record for water level changes spanning the entire Holocene has been generated. Lake level highstands occurred at 9.3-9.0, 8.3-7.8, 6.0, 4.6-4.2 and 3.0 cal ka BP. In addition, some brief intervals of low sea level are indicated by maxima in the concentrations of carbonate and dissolved salt. Gradually decreasing carbonate and dissolved salt contents in the sediments are clearly shown for the last 1 cal ka BP, followed by yet another increase during the last 100 years assigned to global warming. The five abrupt water level change events may indicate that the Southwest Monsoon experienced five sudden advances into the inland area of the Tibetan Plateau during the Holocene.

ZIGETANG LAKE, WATER LEVEL CHANGES, CARBONATE CONTENT, TIBETAN PLATEAU

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Numerical simulation of East Asian environment under different topography and sea-land distribution conditions

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A lot of research has illustrated that the Eocene environmental pattern in China was dominated by roughly zonal climates resulted from the planetary wind system. Conspicuous changes had occurred for the Neogene when the originally arid south-western and south-eastern part of the country became much more humid and the geographic location of arid region in the north China was further close to the present-day one, indicating the initiation of the East Asian monsoon

and inland-type aridity. However, there is a dispute about the reason and mechanism of the change, especially about the effect of Tibetan Plateau uplift and Paratethys sea shrinkage. Here, we use IAP_AGCM and 24 completed numerical sensitive experiments to simulate the change of precipitation patterns in East Asia under the different sea-land distribution and Tibetan Plateau topography conditions. The results illustrate that both Tibetan Plateau uplift and Paratethys sea shrinkage play important roles in the formation of arid inland-type environmental pattern. And the arid inland-type environmental pattern comes into being when Tibetan Plateau is 1000-2500 meters high and Paratethys sea shrinks to Turan Plate. The further uplift of Tibetan Plateau and shrinkage of Paratethys sea can reduce the precipitation and increase the aridity in northwestern country, but cannot change the environment pattern.

EAST ASIA, ENVIRONMENTAL PATTERN, TIBETAN PLATEAU, PARATETHYS SEA, IAP_AGCM

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Records of carbon and oxygen isotopes and paleoclimate reconstruction from a stalagmite from Shuinan Cave, Guilin

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The time sequence of paleoclimatic change from 245.2 ka BP to 147.9 ka BP has been established by the dating ages of the high precision TIMS-U series and the analysis of oxygen isotopes from stalagmites of Shuinan Cave in Guilin area, and confirmed that the boundary ages of stage (3)/(2) and stage (2)/(1) are 192.6 ± 3.9 ka BP (corresponds to the deep-sea core oxygen isotope stage 6/7), 242.5 ± 6.4 ka BP (corresponds to the deep-sea core oxygen isotope stage 7/8) respectively which is got by using TIMS-U series dating age at 86.5 cm on the stalagmite section and depositional cycles of the stalagmite section and the sudden change characteristics. The study result indicated that the paleo-climate (or paleo-monsoon) change reflected by the cold and warm events of the stalagmite record during 245.2 ka BP and 147.9 ka BP can be divided into three stages of climate change: (1) the period from 245.2 ka BP to 242.6 ka BP corresponds to the last

stage of the deep-sea core oxygen (SPECMAP) stage 8; (2) the penultimate interglacial period from 242.5 ka BP to 192.6 ka BP corresponds to stage 7 of the deep-sea core oxygen curve (SPECMAP curve); (3) the penultimate glacial period from 192.6 ka BP to 147.9 ka BP corresponds to stage 6 of the deep-sea core oxygen curve (SPECMAP curve). The records of TIMS-U series dating ages and stable isotopes from the stalagmite revealed that the evolution history of the East Asian monsoon from 242.6 ka BP to 147.9 ka BP occurred in Guilin area were good provided with the paleo-climate and paleo-monsoon changes revealed by the records of the deep-sea core oxygen isotope stage 6 and 7, spore-pollen combination and CaCO_3 content from the deep-sea core records and loess and paleosol from the North China, rose and fell in the sea level, forming soil and complete iron accumulation degree of loess and paleosol, magnetization rate change and the original crumb CaCO_3 content and eluviation intensification from the North China and so on. These characteristics showed that the paleo-climate evolution since the late stage of the middle Pleistocene Epoch in Guilin area not only have the global characteristics but also have the strong district characteristics.

STALAGMITES, TIMS-U SERIES AGES, ISOTOPE RECORD, PALEOCLIMATE RECONSTRUCTION, SHUINAN CAVE

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High-resolution studies on the activities of dust storms over the Chinese Loess Plateau since 8500 yr BP

Jingbo Zhao

The Holocene loess on the Chinese Loess Plateau constitutes an excellent record of dust storm activity. The high-resolution loess profiles on the Bailuyuan tableland at Xi'an and on the Linyuan tableland at Baoji were studied by grain-size analysis and measurement of CaCO_3 . The results provide new material of dust storm activity in the areas. Increased intensity of dust accumulation has occurred since ca.

3100 yr BP in the areas. A thick recent loess (Lo) of 150~180 cm that overlaid the Holocene paleosol (S0) had been found. Both the field observations and the analytical results reveals: (1) the great change of dust storms activities from weak to strong happened at ca. 3100 yr BP and resulted in a loess accumulation rate of 7 times more in the Later Holocene than in the Middle Holocene. (2) Great dust accumulation rate was controlled mainly by arid climate. Usually, loess developed in dry-cold glacial period. However these studies confirmed that loess could develop fast in the semi-moist and semi-arid interglacial period, and the accumulation rate in the Late Holocene interglacial period is faster than that in last glacial periods. (3) There were 8 strong stages and 8 weak stages of dust storm activities since 3100 yr BP (4) The high frequency of dust storms activities in recent years in China is caused by the modern warm-arid climate and modern times is still in the strong period of dust storms activities.

DUST STORMS, DUST ACCUMULATION, LOESS, HOLOCENE, LOESS PLATEAU

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Climate change and human impact on the Song Hong (Red River) Delta

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On the basis of the results of palynological research on two cores from the Song Hong (Red River) delta in the sub-tropical zone of Asia, centennial- to millennial-scale climate changes and human impacts during the Holocene were clarified. Especially three cycles of cooling and warming were identified during the last 5000 yr: a cool and wet climate during 4530-3340 cal yr BP, 2100-1540 cal yr BP, and 620-130 cal yr BP, a warm and dry climate during 3340-2100 cal yr BP, 1540-620 cal yr BP and the present warm climate. The first and last cooling events correspond to global Holocene cooling events, the Neoglacial Period and the Little Ice Age, respectively. Each persisted for 500-1000 yr, and they occurred at intervals of 1500-2000 yr. Pollen records also reflect human impacts on this area, which intensified after 3340 cal yr BP when large quantities of cultivated Gramineae taxa, possibly including the main wet rice species, *Oryza sativa*, secondary forest, and other upland cultivated taxa appear in the record.

PALYNOLOGY, CLIMATE CHANGE, HOLOCENE, SONG HONG (RED RIVER) DELTA, HUMAN IMPACT

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Modern pollen-vegetation-climate relationship in East Asia: Implication for climate reconstruction

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The East Asian region is a unique region in the old-world in possession of continuous forest cover through the tropical to the frigid zones. The forest as dominating natural vegetation in the eastern part is closely associated with temperature gradient from north to south, and the increasing xerophytic formations in inland areas of China associated with precipitation gradient from east to west. The pollen rain study in this subcontinent reveal the good relation of the present-day pollen distribution with the ecosystem and climate on a continental scale, and this make it possible to set up a relatively high-resolution pollen-based vegetation map of the regions. The present work of this study has established a preliminary pollen database of the East Asia with more than 1400 sites from 7 countries. A great number of Quaternary records in the East Asia revealed that the vegetation boundaries greatly shifted along latitude and altitude through glacial and interglacial periods. To quantitatively study this displacement, Quaternary pollen diagrams need to be interpreted by comparing numerically with modern sites that have similar pollen proportions. Typical Quaternary coring profiles have been selected for high-resolution studies using quantitative climate reconstruction method (analogue method) based on the present pollen database. The result of quantitative reconstruction showed that vegetation boundaries have shifted at least 8° latitude southwards in eastern China and lowered 500-800 m of altitude in tropical-subtropical mountains during the LGM. The result of shift extent of vegetation and climate on the East Asian continent is accordance with the previous studies and the models of global changes. The present study showed that the information from modern pollen studies is very important and potentially valuable for vegetation and climate reconstruction. This work was supported by the National Natural Science Foundation of China (NSFC: 40331011).

POLLEN DATABASE, VEGETATION, CLIMATE RECONSTRUCTION, QUANTITATIVE METHOD

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Optically stimulated luminescence dating sand-loess system in Mu Us and Otindag Deserts in North China

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The loess-sand transition zone in northern China is sensitive to reflect climate changes. However, the optically stimulated luminescence dating (OSL) has not been well used in these eolian deposits in this region. Quartz grains extracted from the sediments for OSL dating have been supposed to be bleached completely, and the OSL dating should be reliable and precise. The Single Aliquots Regeneration (SAR) method, which has been examined to be a successful method for dating the desert deposit, was used to date the sand-loess system in the Mu Us and Otindag Deserts in north China. Combining proxy indicators measurement, our results provide a preliminary chronology for the wet-dry variations during the past 60,000 years in the dunefield area, and the OSL dating are comparable with the previous investigation of radiocarbon results. There are millennial timescale climatic events, which are tentatively correlated with the paleoclimatic events in the other regions, such as the north Atlantic. The dry events in the desert and dune fields probably related the cold events in the north Atlantic region. From the dose recover experiment, it is hypothesized that the large scatter of D_e values and OSL signal may be related to heterogeneous microdosimetry, bioturbation, etc. This needed to be further investigated. However, the OSL date should provide precise age constraints for dynamics of sand-loess system in this region.

OPTICALLY STIMULATED LUMINESCENCE DATING, LATE QUATERNARY, MU US DESERT, OTINDAG DESERT, WET-DRY VARIATION

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High-resolution evidence of an early Holocene optimum and a mid-Holocene dry event from southern China during the last 18,000 years

Weijian Zhou

Computer models suggest that the Holocene Optimum for the East Asian summer monsoon precipitation occurred at different times in different regions of China. Previous studies indicate that this time-transgressive Holocene Optimum should have been experienced about 3000 yr ago in southern China. Here, we describe a section that allows us to directly test this timing. We have closely examined high-resolution eutrophic peat/mud sequences covering the last 18,000 cal yr at Dahu, Jiangxi, on the southern boundary of the mid subtropical zone in China. Late Pleistocene successions in the Dahu record indicate cooler and much-wetter conditions relative to synchronous events in north-central China. Our results indicate that the Holocene Optimum occurred between ca. 10,000 and 6000 cal yr ago in southern China, consistent with the global pattern. Conditions were relatively dry and cold from 6000-4000 cal yr ago. Our data also support the conclusion that the last deglaciation to early Holocene in the south was much-wetter, resulting in the formation of dense broad-leaved forests, which could have acted to moderate land temperature ~10,000 to 6000 cal yr ago, yielding a stable early-Holocene climate. After 6000 cal yr, forest reduction led to unstable land temperatures, and possibly to a northerly shift of the subtropical high pressure system. Whatever the mechanism, these changes resulted in decreased precipitation between 6000 and 4000 cal yr BP in southern China.

LACUSTRINE SEDIMENT, EUTROPHIC PEAT, AMS ^{14}C DATING, HOLOCENE OPTIMUM, MONSOON PRECIPITATION

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Carbon isotopic records from stalagmites and the signification of paleoecological environment in the area of Guangxi-Guizhou

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High-resolution carbon isotopic records in millennial, centennial and decade timescale from three stalagmites from tree caves in the area of Guangxi-Guizhou, China, provide a detailed information of paleo-ecological environment in the past 15,000 years. The results indicate that in the glacial period or cold-dry period such as Heinrich event H1 and Younger Dryas event, lack of karst development, soil-forming is slow for poor condition, which hampers vegetation grow, resulting in C4 plant dominant with the heavy $\delta^{13}\text{C}$ value. Otherwise in warm-humid stage with well karst development, soil-forming is fast for good conditions, and vegetation grows well, thus C3 plant predominates with the negative value. Since late Holocene, human activity may predominate instead of the nature factors, the forest vegetation was destroyed continuously but grass grew well, and C4 plant became the dominant vegetation, the $\delta^{13}\text{C}$ value of stalagmites increasing sharply, rock desertification aggravating because of serious water and soil erosion, which make the heavier $\delta^{13}\text{C}$ value unable back to the level of pre-middle Holocene. By discussing the effect factors of $\delta^{13}\text{C}$ value change from stalagmites, we considered that both the nature factors and human activity could result in the vegetation change, and this vegetation change in term of $\delta^{13}\text{C}$ value could be enlarged double, decade times, and hundred times. In particular, nature ecological environment is more sensitive to human activity, which doesn't only bring about the degeneration of forests and vegetation, leading to $\delta^{13}\text{C}$ value change from stalagmites, but also aggravate rock desertification and serious water and soil erosion in karst region.

STALAGMITES, CARBON ISOTOPIC RECORDS, ROCK DESERTIFICATION, GUANGXI-GUIZHOU, C4 PLANTS

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Meeting Program:

The Registration & Information Desk in the lobby of the BICC will be open at the following times:
Tuesday, 9 August 10:00 - 20:00; Wednesday - Friday, 10-12 August 8:30 - 17:30

Note: All posters will be on display from Wednesday to Friday.

Tuesday, 9 August 2005

19:00 WELCOME RECEPTION — Beijing International Convention Center
Courtesy of Chinese Academy of Sciences, Institute of Geology and Geophysics

Wednesday, 10 August 2005

8:30 Welcome Lecture — *Yiyu Chen, Dongsheng Liu, Zhongli Ding, Thorsten Kiefer*

Session 1. Future Change: Historical Understanding - Chair: Julie Brigham-Grette

9:00 *Michael Mann, USA* — Insights from Comparing Empirically-estimated and Modeled Climate Change in Past Centuries
9:30 *James Shulmeister, New Zealand* — Interhemispheric Linkages in Climate Change: Paleo-perspectives on Modern Problems
10:00 *Ricardo Villalba, Argentina* — Long-term Variability in Tropical and High-latitude Circulation Modes of Climate in the Americas
10:30 COFFEE/TEA BREAK
11:00 *Valérie Masson-Delmotte, France* — Dynamics of Global Climate and Water Cycle Changes: Interest of Quantitative Paleoclimatic Reconstructions
11:30 *Bette Otto-Bliesner, USA* — Climate Sensitivity Derived from PMIP-2 Model-Data Intercomparisons for the Last Glacial Maximum and Mid-Holocene
12:00 *Michael Schulz, Germany* — Past Climate Variability at Centennial-to-millennial Timescales: Does it Matter for Predicting Future Climate Change?
12:30 LUNCH

Session 2. Humans and their Environment: Past Perspectives on Sustainability - Chair: Daniel Olago

14:00 *Mohammed Umer, Ethiopia* — Climate Change, Human Evolution and Later Adaptation in the Horn of Africa and the Surrounding Regions: Potential for Long Climate Record In Ethiopia
14:30 *John Dearing, UK* — Human-Environment Interactions: Past, Present and Future
15:00 *Rick Battarbee, UK* — Paleolimnology, Pollution and Climate Change
15:30 Open — Talks by presenters of meritorious abstracts
16:00 Posters I (with drinks and snacks): Session 1 and Session 2

Thursday, 11 August 2005

9:00 *Charles Redman, USA* — Human Impacts on Ancient Environments
9:30 *Rudolf Brázdil, Czech Republic* — Human Impacts on Climate Anomalies and Weather Disasters during the Past Millennium in Central Europe: Learning from the Past
10:00 *Frank Hole, USA* — Sustainability in the Period of Agriculture: The Near Eastern Case

10:30 COFFEE/TEA BREAK

Session 3. Ocean-Continent-Cryosphere Interactions: Past and Present - Chair: Pinxian Wang

11:00 *Hubertus Fischer, Germany* — Global Biogeochemical Cycles and Greenhouse Gas Emissions in the Ice Core Paleoperspective
11:30 *Paul Mayewski, USA* — Reconstructing the Last 2,000 Years of Climate through ICARA (Ice-core Climate Archive Recovery Activity)
12:00 *Sandy Harrison, UK* — Towards Modeling the Ice-core Record of Atmospheric Trace-gas and Aerosol Variations between Glacial and Interglacial Times
12:30 LUNCH
14:00 *Olga Solomina, Russia* — Climatic events and tendencies in the North-West Pacific recorded by trees and glaciers during the last 400 years
14:30 *Stephen Burns, USA* — The Tropics and Rapid Climate Change - Records of Changes in Rainfall and Atmospheric Circulation from Speleothems
15:00 *Ralph Schneider, Germany* — From Milankovitch to Rapid Climate Change, IMAGES Research
15:30 *Gavin Schmidt, USA* — The Thermohaline Circulation in Past, Present and Future Climate
16:00 Posters II (with drinks and snacks): Session 3 and Session 4 (Western Pacific Margin sub-theme)

19:00 CONFERENCE BANQUET

Friday, 12 August 2005

Session 4. Climate, Humans and the Environment in the Asian Region - Chair: Peter Kershaw

9:00 *Patrick De Deckker, Australia* — The Role of the Indo-Pacific Warm Pool on Global Climate Change during the Quaternary
9:30 *Zhimin Jian, China* — Millennial-centennial-scale Climate Variability of the Low Latitude Western Pacific during the Late Quaternary
10:00 *Zhisheng An, China* — The Evolutional Process of Asian Dust and its Role for the Earth System in the Past
10:30 COFFEE/TEA BREAK
11:00 *Gifford Miller, USA* — Detecting Human Impacts on the Flora, Fauna, and Summer Monsoon of Pleistocene Australia
11:30 *Ashok Singhvi, India* — Monsoon and Man in the Indian Sub-Continent
12:00 To be announced
12:30 LUNCH
14:00 Plenary Discussion: PAGES Future Direction — *Zhengtang Guo, Julie Brigham-Grette*
16:00 Posters III and award of poster prizes (with drinks and snacks): Session 4 (except Western Pacific Margin sub-theme)