# Environmental processes of East Eurasia: the coordinated effort to address forcing and feedbacks in the large-scale changes in the Northern Hemisphere climate

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On November 7—9, 2010, the 8th International Symposium "Environmental Processes of East Eurasia: Asian Monsoon Changes and Interplay of High and Low Latitude Climate" took place in Kunming, China. This is the most recent of the series of annual to bi-annual Symposia, previously held in Mongolia, Russia, Japan, Korea and China. In addition to representatives of research institutions from these countries, the Symposium was also attended by participants from USA and Germany. The two and a half day program, which included 28 oral and 20 poster presentations and an open discussion, was followed by the field excursion to the Heqing Basin in China's Yunnan Province, the site of the recent drilling of a long sequence of lacustrine sediments to the southeast of Tibetan Plateau.

For the past decade, regular Symposia "Environmental Processes of East Eurasia" provided the platform for exchanging ideas and building international collaborations to address past environmental and climate changes in continental setting. Originally centered on the long multi-million year records of subaerial loess/soil sequences of the Loess Plateau of China and lacustrine sequences from the Baikal rift basins, previous Symposia were instrumental in developing a number of subsequent large international projects in continental Asia. The recent Lake Hovsgol Drilling Project (Mongolia), Lake Qinghai Drilling Project (China) and Heqing Drilling Project (China) recovered new sediment records from Asian lake basins to address past regional climate changes. Actively studied at the moment, these records help shaping the new understanding of key processes, which determined the evolution of Eurasian climate during the Quaternay and during the late Pleistocene-Holocene.

One of the key features of East Eurasian continental records is their remarkable duration and continuity, resulting from the deposition of aeolian and lacustrine sediments in relatively stable settings. As established previously and confirmed in the most recent long records, a strong presence of orbitally-driven periodicity in sediment deposition and sediment properties provides solid basis for developing continental timescales compatible with that of marine oxygen isotope records. The results on the newly developed regional records and proxies presented at the Symposium consistently point to several prominent steps in the evolution of environment and climate in East Eurasia. These include the large-scale shift in precipitation and wind patterns between ca. 3.2 and 2.8 Ma, the step-wise intensification of the amplitudes of proxy responses at ca. 1.25 Ma, and between ca. 0.6 and 0.4 Ma during the mid-Pleistocene.

Among the traditional themes for Eurasian Symposia are the interplay and the potential linkage between tectonics and climate: the discussion of the role of the Tibetan Plateau, the largest orographic anomaly on Earth, in shaping the climate of East Eurasia. New developments in Eurasian records help distinguishing the depositional signals (grain size, sedimentation rates and terrigenic fluxes) in a growing number of sedimentary basins across several climatic zones from regional paleoclimate proxy signals. This work in progress will eventually allow stepping beyond the circularity of argument regarding tectonics and climate, which is often viewed as 'chicken and egg' problem when dealt with in individual records.

The 8th Symposium "Environmental Processes of East Eurasia" showed the progress of how the vast geographic network of new East Eurasian records is expanding latitudinally across climate zones. We build a network of records with (a) similar time span, (b) compatible orbitally-tuned timescales and (c) multiple proxies (whose nature is better understood now) to systematically address the relative changes in the advection of heat and moisture to continental interior via the Asian monsoon and the Northern Hemisphere westerly atmospheric circulation systems.

The influence of westerly circulation in East Eurasia is a prominent developing theme in regional paleoclimate studies. The importance of the interplay between monsoon and westerlies is highlighted in the ongoing studies of Lake Qinghai sediment record. Further to the north, Lake Hovsgol sediments contain the first carbonate oxygen isotope record from the Baikal rift zone, with the potential to distinguish hydrological changes in the basin (seen in lithology, carbonate mineralogy and sediment geochemistry) from the atmospheric signal of changes in the isotope composition of precipitation.

The important new development in the studies of East Eurasian records, which was highlighted at the Symposium, is the possibility of distinguishing seasonal winter and summer proxy signals within a single record (e.g., quartz grain size and magnetic susceptibility in loess/soil records). The strong seasonality and different nature of the proxies thus allow exploring past changes in the coupling of winter and summer processes, which are driven by different atmospheric circulation systems, for example, the relative intensity and the coupling mode of winter and summer monsoons in Asia.

A similar new development in East Eurasian studies is the possibility of distinguishing regional precipitation and temperature signals (e.g., terrestrial vegetation successions in lake watersheds in the well-resolved lacustrine records of Plio-Pleistocene interglacials). The recent Symposium highlighted the potential of resolving the interplay of these signals, for example, Lake Baikal palynological signals were used to constrain temperatures of winter and summer

during past interglacials. Because palynological successions are internal to each individual paleoclimate record, future studies are expected to reveal common geographic patterns indicative of the interaction of large-scale atmospheric circulation systems.

The interaction of the high and low latitudes is an important theme driving the data-model comparison efforts presented at the Symposium. Consistent with the data on speleothems from China and temperature oscillations in Greenland ice core records, current models strongly indicate the existence of teleconnections between Asian monsoon(s) and temperature conditions in the North Atlantic, the linkage through atmospheric circulation appears more likely than that through snow cover or tropical sea surface temperatures.

The significance of interhemispheric forcing in driving the Asian monsoon circulation system is another new theme developing at our Symposia. One aspect of this forcing is the significance of cross-equatorial southerly-southwesterly wind flow carrying summer moisture from the southern Indian Ocean source to feed the modern 'Indian' and 'East Asian' monsoon systems. Another aspect is the significance of interhemispheric low-latitude insolation gradient (30ºN~30ºS) in driving Asian summer monsoon as suggested by the novel $^{10}$Be proxy in the Chinese loess/soil records.

Increase in process-oriented studies including numerical simulation and model experimental study is another important trend in the symposium. These are of great significance for proper interpretation of the data obtained and future prediction which is one of essential missions imposed to our science.

Having started as a regional tradition, the Symposia "Environmental Processes of East Eurasia" have significantly developed over the past decade, as an adequate reflection of the developments in Eurasian paleoclimate studies in general. Greatly improved research infrastructure is seen from the abundance of new high-quality data, new sophisticated proxies, high density of radiocarbon dates in the new records. Greatly improved exchange across international boundaries is seen from multiple ongoing collaborative efforts between Chinese, Japanese, Mongolian, Korean, Russian and US research institutions. Greatly increased visibility of Eurasian studies is seen from multiple new high-impact factor publications coming out every year and in regularly emerging new paleoclimate records, particularly, drill cores of long lacustrine sequences.

Scientifically, our Symposia have significantly developed as well, with a general shift from proxy-oriented research at individual sites to processes-oriented synthesis studies and to broader participation of modeling community. New collaborative efforts now allow critical re-evaluation of some long-held concepts in our research fields, such as the timing and the role of Tibetan Plateau uplift, the origin of the monsoon, and the interaction between different atmospheric circulation systems.

Rather than being just a report on the most recent regional science meeting, this summary is intended as an invitation to further develop paleoclimate studies of East Eurasia utilizing the existing tradition, format, expertise and network of Symposia "Environmental Processes of East Eurasia". For future Symposia, we plan to broaden the participation of research communities somewhat underrepresented at previous meetings, including the glaciological history of continental East Eurasia and the biotic evolution linked to past climate change. A strong emphasis will be put on facilitating the data-model comparisons: modeling of the moisture transport in the Northern Hemisphere westerly circulation system and the interhemispheric mechanisms of moisture transport in Asian monsoon system. The new thinking on hemispheric and inter-hemispheric forcing mechanisms of climate change on one hand, and the continuously improving and expanding new high-resolution regional paleoclimate data sets with seasonal (rather than annually-averaged) signals on the other hand, provide a great opportunity to develop new understanding of functioning of the Earth's climate system, from short-term millennial timescales to long-term evolution over millions of years.

## Identification of Greigite in the late Pleistocene sediments of Lake Qinghai

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Abstract: In this study, the magnetic mineralogy of a late Pleistocene lake sediment core (1F, ca. 18.6 m long) from the southern sub-basin deposition center of Lake Qinghai, the largest lake in China, was studied using multiple rock-magnetic and non-magnetic measurements. There are two distinct magnetic susceptibility peaks at the depths of 8.15~8.96 m and 15.50~17.28 m. High and low temperature magnetization investigations, coupled with scanning electron microscopy (SEM) and Energy dispersive x-ray (EDX) analyses, suggest that the sediments from these two intervals contain a large number of single domain (SD) and superparamagnetic (SP) greigite particles, which is the primary cause for the enhancement of magnetic susceptibility. These greigite particles are mainly formed due to sulfate reduction. The occurrence of greigite in the late Pleistocene sediments of 1F core implies that the Lake Qinghai could have experienced two intervals favorable for early diagenesis during the late Pleistocene.

Key words: Lake Qinghai; lake sediment; greigite; rock magnetism; environmental magnetism

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## Paleoenvironmental changes in southern Siberia during the Late Pleistocene and Holocene - evidence from multiproxy records of the Lake Baikal Region

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Abstract: Worldwide terrestrial and marine sedimentary archives demonstrate that the last 50 ka interval in the Earth's history experienced a number of long- and short-term climatic oscillations. High-resolution and accurately dated pollen and sedimentary records of the late-glacial/early Holocene interval exist for several regions of Europe and East Asia, providing important insight into the environmental dynamics in the North Pacific and North Atlantic regions. However, a recent global-scale synthesis of the Holocene climatic data demonstrates a lack of palaeorecords of comparable dating quality and resolution from the vast areas of Eurasia, including Siberia. The dating problem becomes even more obvious, when the pre-Holocene interval of the late Quaternary is considered.

Southern Siberia— the region of Russia between ~80—120°E and ~50—60°N — consists of numerous sub-latitudinal mountain ranges and lakes, including Lake Baikal in the east. The lake sediments are one of the most promising sources of detailed palaeoenvironmental information, which provide an opportunity for bridging the European and Asian palaeoclimate archives and addressing critical questions concerning Quaternary climatology and palaeoecology. Numerous publications on the Lake Baikal region presented coarse-resolution (millennial- or multi-century-scale) qualitative reconstructions of the Quaternary environments. Although the long cores from Lake Baikal span millions of years research was mainly focused on the Holocene and earlier interglacials. However, little is known about glacial intervals due to the problems associated with very low pollen concentrations, poor organic content, low sedimentation rates and poor dating. Until recently, even the YD cooling was not unequivocally identified and dated in the Baikal records.

This study presents new pollen and diatom records from Lake Kotokel and several regional peatlands, and aims to reconstruct regional vegetation and environmental history since ~47 ka BP (1 ka=1000 cal a); to compare it with the oxygen isotope records from the North Atlantic and North Pacific regions; and to discuss the underlying mechanisms of the environmental change in the region.

The relatively high temporal resolution and reliable AMS-based age model of a new record enable its comparison with the reference palaeoclimatic archives representing North Atlantic and North Pacific regions. This comparison suggests that the reconstructed shifts in late Pleistocene—Holocene vegetation and environments in the Lake Baikal region could have been controlled by the major factors controlling NH climate. The correspondence between the KTK2 record and very high-resolution isotope and pollen records from far distant North Atlantic and North Pacific regions implies that southern Siberia, despite its location in the interior of the Eurasian landmass, responded swiftly to global change. This conclusion is a key point in the ongoing debate on the synchronic/non-synchronic environmental dynamics of terrestrial environments within the Lake Baikal region during the last 15 ka, based upon less accurately dated previous pollen records.

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Key words: Late Pleistocene; MIS 3-1; changes in vegetation cover and climate; southern Siberia; chronology; forcing; feedback

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## A review of Holocene climate records on the Tibetan Plateau based on pollen records

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Abstract: We present a recently published pollen record from the Hongyuan peatland in the Zoige Basin that reveals the long-term dynamics of an alpine wetland ecosystem on the eastern margin of the Tibetan Plateau over the last 13500 years. Changes in pollen assemblages and influx rates suggest that local vegetation has experienced three distinct stages at the site, from alpine coniferous forest–meadow (13500~11500 cal a BP), through alpine coniferous forest (11500~3000 cal a BP), back to alpine coniferous forest–meadow (3000 cal a BP—present). This record reflects an ecosystem response along a transition zone where the South Asian and East Asian monsoon systems may have had

different paleoclimatic influences. This review focuses on a comparison of this record with other published pollen records across the Tibetan Plateau. At each site it is possible to identify an optimal growth period during the Holocene. The age model of each site is carefully scrutinized to assure that the assumptions applied at every site are consistent and that there is sufficient age control for a detailed comparison. It is shown that the chronology of the Hongyuan site is by far the most tightly controlled among all of the published records. The Holocene optimum is broadly similar over a large portion of the Tibetan Plateau, however a pattern of regional, temporal and spatial variability is clear. Most of the records show optimal growth conditions around 6 cal ka BP, but the initiation and duration of this optimum is quite different from site to site. The optimum starts anywhere from the beginning of the Holocene to about 8 cal ka BP. Nearly all of the records show relatively dry conditions after about 4 cal ka BP. The differences in these records could result from variable climatic influences at each site, or they might stem from local growth conditions that interfere with an accurate regional pollen picture. Inadequate age control could also contribute to the observed differences. The Hongyuan record demonstrates the usefulness of high temporal resolution in reconstructing Holocene climate from pollen records.

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## Tree-ring-based temperature reconstruction for Lüliang Mountains, China, since AD1836

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Abstract: The long-term regional climate history can be studied by a range of climate proxies—ice cores, stalagmites, corals and documentary material, as well as tree rings. Among those proxies, annual resolved tree rings serves as one of the best proxies for recording climate change over the last millenniums. In this study, a May—July temperature proxy extending back to 1836 was developed from tree-ring width of Chinese pine (*Pinus tabulaeformis* Carr.) found in the middle Lüliang Mountains, northern China. Correlations analysis indicated a strong response of tree-ring index to May—July mean temperatures, which were subsequently reconstructed. The reconstruction captures 45% ($F$=38.474, $p$<0.001) of the regional variance in the instrumental data over the calibration period 1955—2003. Reconstructed warm and cold periods were verified by additional temperature reconstructions based on tree-ring data from northern China. In addition, the reconstruction was significantly correlated with May—July mean temperatures from 13 other meteorological stations in northern China, suggesting that our reconstruction is also representative of north-central China. The warming trend during the second half of the 20th century is seen in the reconstruction, but only the 1994—2002 mean temperature seems unprecedented over the whole reconstructed period.

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## Black carbon records in Chinese Loess Plateau and its implication for paleo-climate change

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Abstract: Fire is a key earth system process affecting ecosystems, land-surface properties, the carbon cycle, atmospheric chemistry, aerosols and human activities. Local fire history has been expensively reconstructed from charcoal records from lake sediments and enables us to infer the impacts of climate changes and human activities. However, long-term fire history at glacial-to-interglacial scale can be available from loess-paleosol sequences. Black carbon (BC) is a kind of material originating from biomass and fossil fuel combustion and can be used as the best indicator of paleo-biomass burning.

BC is not one chemical compound or a group with well-defined characteristics, but a suite of compounds occurring along a "combustion continuum" that can be differentiated into two parts of carbon contents: combustion residues from pyrolysis and combustion emissions formed via gas-to-particle conversion, corresponding to char and soot. Char is composed mainly of micrometer particles and generally retains the morphology of its source material, and in which the countable part identified under the microscope (generally >5 μm) is called charcoal. Soot is composed mainly of submicron particles formed from the condensation of hydrocarbon radicals at high temperature (>600°C). Due to differences in the chemical and physical properties of char and soot and the resulting differences in light-absorbing properties, the differentiation between char and soot in the environment would help us better understand

their environmental and climatic impacts.

Loess covers an area of about 440000 $km^2$ in the Loess Plateau of north–central China. Loess and paleosol consist of the sequences of the Loess Plateau and represent the different climate periods. Generally loess deposited in glacial periods, while paleosols deposited in interglacial periods.

BC, char and soot contents in Lingtai and Luochuan loess sections are analyzed using the thermal optical reflectance (TOR) method to investigate the spatial-temporal changes in natural fires and its relations with the paleo-climate over the last glacial cycles. The average concentrations of BC, char and soot are 0.475, 0.314, 0.161 $mg \cdot g^{-1}$ in Lingtai sections, which is about 2 times higher than those in Luochuan section. This may be associated with the different biomass coverage in the two areas. The average char/soot ratios in the two sections are very close, varying from 2.42 to 2.58. Vertical profiles of BC and char contents have similar trends in the two sections and show similar variations. High BC and char concentrations occurred in warmer and humid periods, while low BC and char concentrations occurred in colder and dry periods. This suggests that in such semiarid area in the Loess Plateau the main factor on biomass fires is from the availability of biomass fuels. In humid period with the increase of the biomass coverage the occurrence of biofires increases. Soot vertical profiles shows very different trends in the two sections during the last glacial. Soot can be used to indicate even broader-scale trends in fire activity because it is dispersed primarily through the atmosphere. Since fire occurrence is generally accompanied with dry conditions, the overall increase in soot concentrations in Lingtai section might be an indicator of gradual intensification of the drought in West China. The correlations of the magnetic susceptibility with BC and char in Lingtai section are better than that in Luochuan sections. The correlations of the magnetic susceptibility with char are better than those with BC in the two sections. This may suggest that BC and char may be the main sources of the loess magnetic susceptibility in the Loess Plateau since fires can produce high magnetic materials, while local fires appears to be the main contributor.

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## Plio-Pleistocene summer monsoon response to orbital forcing: synthesizing marine, loess, and paleolake records

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Abstract: Long (Plio-Pleistocene) summer monsoon records have now been produced from the Arabian Sea, South China Sea and Chinese Loess Plateau, representing both the Indian and East Asian monsoon sub-systems. All records have all been placed on the global marine benthic oxygen isotope time-scale (LR04). These Indian and East Asian records are synthesized to evaluate the timing of maximum summer monsoon circulation relative to external insolation forcing at the Earth-orbital obliquity and precession bands and to infer from these relationships, the primary internal and external mechanisms driving changes in monsoon strength at orbital time scales.

Summer-monsoon records from all three locations have similar phase responses at the obliquity and precession bands indicating that the Indian and East Asian systems are tightly coupled and driven by common forcing mechanisms throughout the past 2.7 Ma.

The common response among the proxy records over the past 2.7 Ma is consistent with the fact that the Indian and East Asian systems have a common energy source; the majority of moisture (energy) entering the Indian and East Asian systems comes from the southern hemisphere Indian Ocean.

At the obliquity band, the phase response indicates that strong monsoons are equally sensitive to sensible heating over Asia, latent heat export from the southern Indian Ocean, and decreased glacial boundary conditions.

At the precession band, the phase response indicates that strong monsoons are sensitive to latent heat export from the southern hemisphere Indian Ocean and decreased glacial boundary conditions. Model results from the fully coupled ocean-atmosphere Fast Ocean Atmosphere Model (FOAM) support this link to latent heat export.

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## Flume experiments on responses of topography at a river mouth to change in external conditions

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Abstract: Flume experiments in which the silty deltas were developed under unsteady flows were conducted. We examined several increasing and decrease rates of flows. Results showed that sedimentary processes of a delta were aggradation at high increase rates of discharge, backstepping at middle rates, and progradation at low rates. In the

phase of decreasing flow, there was hysteresis in the development process. Even if the decrease rate was the same, the process of topographic change was different according to the previous state of the delta shape. Besides we found that the development processes related with the sediment balance (erosion-sedimentation) on the topset bed that was quasi-equilibrium state at low increase rates of flow discharge, but was non-equilibrium state at high increase rates of discharge.

Key words: Flume experiment; river; delta

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## Origin of the yellow-brown earth sediment on the bottom of Yilangjian core from Lake Qinghai and its environmental implication

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Abstract: Lake Qinghai is situated on the northeastern Tibetan Plateau, which has played an important role in research fields about climate environment evolution and recent uplift of the Tibetan Plateau, as well as questions about regional tectonics and the evolution of sedimentary basins in this area. Yilangjian core, drilled from the Yilangjian terrace on the southern shore in 2005, is located in the southern depression of Lake Qinghai. A 626.39 m long core from Yilangjian area reveals sedimentary stratum stable and continuous generally, and it can be easily divided into two parts according to lithology characteristcs of the core. The upper 584.64 m of core consists of continuous lacustrine silty clay interrupted partly by coarse sand and silt, and the underneath core from 586.64 m to 626.39 m in depth is the yellow-brown earth sediments, which is different from the upper lacustrine sediments obviously. In order to make clear the origin of the yellow-brown earth sediment on the bottom of Yilangjian core, firstly, the yellow-brown earth sediment lithology characteristic were observed, and most earth sediment are underlain by carbonate concretion horizons similar to those in Quaternary loess. Secondly, we present results of grain-size analyses of the yellow-brown earth sediment on the bottom of Yilangjian core from Lake Qinghai, and in particular their grain-size distribution is compared with that of typical aeolian loess—paleosol, red clay, as well as lacustrine and fluvial sediments. It appears from the sedimentological evidence that the major part of the yellow-brown earth sediment is of aeolian origin. It is rather similar in some of its properties to the red clay. Thirdly, Quartz grain morphology in earth sediment shows clearly subangular to subrounded shape and collision pits which are characteristic of aeolian dust deposits, and are clearly different from Quartz grain morphology in typical lacustrine sediments in upper core. The study into the stratigraphy of YL drilling core indicates that the typical lacustrine deposit starts at the depth of 586.64 m, and the paleomagnetic age at this depth is 4.64 Ma.Therefore, the abrupt climate transformation event had been defined from the change from aeolian dust deposits to lacustrine sediments, which occurred at about 4.64 Ma. Meanwhile, it is inferred that, in modern meanings, Lake Qinghai may also come into being at 4.64 Ma.

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## Mineralogy of long drill core from Darkhad Basin in northern Mongolia

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Abstract: Darkhad Basin in northern Mongolia was former dammed lake during Pleistocene glaciations. The basin is located in the inside of continent where is sensitive to the climate change. The lake sediments are expected to possess the paleo-environmental records like the sediments from Lake Baikal and Hovsgol. Three long drill cores were obtained from the Darkhad Basin at winter of 2010. This study is first report for the mineralogy of the long drill core from the Darkhad Basin.

DDP10-3 core (alternatively "Hodon core"; 51°20'11"N, 99°30'4"E; length about 164 m) was used for the mineralogical investigation. The sample was cut into 3 cm and analyzed from top to 30 m by means of X-ray powder diffraction (XRD) after freeze-drying. XRD analyses of bulk sample show that the constituent minerals present in the sediments were quartz, feldspar, amphibole, calcite, dolomite, mica chlorite and smectite. Quartz, feldspar, amphibole, chlorite, mica and smectite were found in samples from all depths. However some samples contain carbonate minerals (calcite and dolomite) whereas some samples do not. The samples with calcite usually contain dolomite. There is no systematic tendency of the presence or absence of carbonate minerals with depth. The formation and dissolution rate of carbonate minerals are much higher than the other constituent minerals. This indicates that carbonate minerals disappear (or appear) during some periods as response to changes of water chemistry of the paleo-lake. The water chemistry is usually affected by surround environment. This preliminary study suggests that the carbonate mineralogy

can be regarded as possible proxy for the paleo-environment in Darkhad Basin.
Key words: Darkhad Basin; long drill core; mineralogy; carbonate; calcite; dolomite

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## Evolution of the East Asian monsoon inferred from environmental magnetic record from Lake Biwa, central Japan

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Abstract: Lake Biwa, located in central Japan, contains a thick sedimentary sequence deposited in lacustrine or fluvial environments during the Pleistocene. Tephrochronology and magnetostratigraphic analysis of deep-drilling cores from the central basin showed that about 800 m thick sediment has been deposited for the last 1.3 Ma . The uppermost 250 m clay unit has provided important paleoclimate records, which can be correlated to major glacial-interglacial cycles for the last 0.45 Ma. Hence, the Lake Biwa sediment is expected to offer detailed records of Asian monsoon activity from the Middle Pleistocene to the Holocene.

We demonstrate that anhysteretic remanent magnetization (ARM), a measure of magnetic mineral content in sediment, provides a good proxy of hydrological changes around Lake Biwa since the last glacial period. While low-field magnetic susceptibility is most widely used for stratigraphic correlation of core samples and detection of paleoenvironmental changes, ARM is more sensitive to concentration of ferrimagnetic minerals such as small magnetite grains. Our previous study on a piston-core recovered in 1995 revealed that the ARM increases in the post-glacial interval and that the variation in the lower part is likely linked to millennial-scale climate changes during the last glacial period. This finding was confirmed by analysis of new piston-cores recovered from other sites in 2007. The ARM records reproducibly extend back to 46 ka, featuring major interstadials of Dansgaard-Oeschger cycles and Heinrich events.

The ARM record shows variation similar to total organic carbon (TOC) content, suggesting that flux of fine-grained magnetite was increased during the post-glacial and interstadial warm periods as well as flux of wash in nutrients and organic matter. A high-resolution pollen analysis showed that the ARM peaks correspond to regional vegetation response with rapid climate changes in the last glacial period. We interpret that the increased ARM represents enhanced precipitation probably associated with higher monsoon activity. The ARM records from Lake Biwa are apparently synchronized with the oxygen isotope records from stalagmites of Hulu Cave in China and the Greenland ice core (NGRIP), suggesting that the monsoon activity is interlinked with regional and global climatic changes. Future analysis of longer core samples from Lake Biwa may provide new insights of the East Asian monsoon evolution since the Middle Pleistocene.

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## TLCI analysis on sediment of Lake Hovsgol

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Abstract: Luminescence dating observes the natural accumulated radiation damage caused by radioisotopes such as U and Th as the form of glow after stimulation by heating or lightening. The luminescence is observed at various wavelength bands and their characteristics have been studied mainly on quartz and feldspar. The emission color of luminescence can be recorded easily by using thermoluminescence color image (TLCI) analysis method for samples artificially irradiated with gamma-rays.

Inagaki et al (2009) investigated the validity of TLCI analysis for boring core samples from Lake Baikal (in Russia), Lake Khuvsgul (in Mongolia) and Byeokgolje (in South Korea). When TLCI analysis is applied to polymineral from lake sediments, the luminous mineral compositions of samples reflect of the regional characteristic and climate of the studied area. If we combine the TLCI with other data, we would be able to obtain information of sample's source and the surrounding environment at the time of deposition.

In this study, HDP04 core sample from Lake Hovsgol was investigated to see color change of glow along depth. Then the acquired TLCI fluctuation was compared with the data investigated by previous studies. All samples were etched with $H_2O_2$ to remove organic matter that does not show any luminescence. A $^{60}Co$ gamma-ray source was used to irradiate samples at Kyoto University Research Reactor Institute. Afterward the photograph of TLCI was taken under a constant temperature of 230 ℃ . The used camera was normal single-lens reflex camera (Canon EOS Kiss Digital N) with micro lens (Canon EF 50 mm f/2.5 Compact-Macro).

To analyze TLCI quantitatively, colored pixels of the photograph were picked up by the program built in this study and then converted to numerical values. Based on Ganzawa et al (2001), color index was calculated from these

numerical values and then were divided into five color ranges.

TLCIs from an aliquot vary and show poor reproductivity, however, the average results varied along depth reflecting characteristics of sediment accumulation at that time. The correlations between the TLCI and data from other analysis (physical analysis, age determination, etc.) will be discussed to understand what is responsible to the change in TLCI.

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## Luminescence dating of bottom sediments from Lake Hovsgol, Mongolia (HDP-08)

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Abstract: To understand the past environmental change using geological archives (e.g., core of sediments or ice), establishing the reliable chronology is one of the most important key issues. Luminescence dating is a powerful method due to its applicability to quartz, which is common mineral found in various kinds of environment, and the datable age range being from present to 100 cal ka. A core of ~18 m in length were obtained in 2008 from Lake Hovsgol, Mongolia (HDP-08) for the purpose of reconstructing the climate-forcing environmental fluctuation in the central continent with high altitude. In this study, optically stimulated luminescence (OSL) from quarts and red thermoluminescence (RTL) from carbonate were measured to estimate depositional ages the sediments. The 16 samples were collected every 10 cm from the core using squire stainless tubes (1 cm × 1 cm) with the length of 4 cm. The surface part, which was exposed to light during core dividing procedures, was then removed in a dark room. After chemical treatment to extract fine grained quarts, OSL were measured. RTL were measured on the bulk sediments based on the thermoluminescence colour images of particular components of sediment. Luminescence was measured by MOSL-11 or MOSL-22 with x-ray source (MEDEC). When the Des estimated from OSL and RTL are compared, they are identical for eleven samples within the error range. To estimate annual dose, concentrations of radioisotopes ($^{238}$U, $^{234}$U, $^{232}$Th and $^{87}$Rb) were measured by laser ablation - inductively coupled plasma - mass spectrometry (LA-ICP-MS). Potassium concentration was measured by X-ray fluorescence spectrometry (XRF). The OSL ages increase from (6.8 ± 3.7) ka to (72.4 ± 13.6) ka along with the depth, but are smaller than $^{14}$C ages. This may be caused by either or both of underestimation of water content in estimation of annual dose and overestimation of $^{14}$C ages due to reservoir effect.

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## Indian monsoon and glacial-induced weathering during early and mid-Pleistocene: evidence of ostracod Sr isotopes from central Tibetan Plateau

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Abstract: The Tibetan Plateau is the key to understanding the East Asian and Indian summer monsoons because of (i) its role in initiating and maintaining monsoon circulations and (ii) its high sensitivity to monsoon variations. One related question is how long-term chemical weathering processes respond to monsoon change.

As bivalved arthropods, the chemistry of freshwater ostracod shells provides valuable information about lake water chemistry. Due to distinct difference between the $^{87}Sr/^{86}Sr$ ratios of seawater and freshwater, the stratigraphic $^{87}Sr/^{86}Sr$ variations of ostracod fossils have been successfully used to trace the transitional marine-lacustrine environment. However, only one work has focused on ostracod $^{87}Sr/^{86}Sr$ ratios to evaluate changing conditions in a truly lacustrine or freshwater system. We provide the first coherent, high-resolution chemical and ostracod Sr-O isotopic records of early to mid-Pleistocene climate variations and chemical weathering processes related to changes in the Indian monsoon system from the central Tibetan Plateau.

Between 2.01 and 0.95 Ma, lake water chemistry was dominated by a high proportion of carbonate weathering related to Indian monsoon variation, resulting in relatively low and constant ostracod $^{87}Sr/^{86}Sr$ but obvious fluctuations in Mg/Ca, Sr/Ca and $\delta^{18}O$ associated with at least six mild to warm climatic cycles. The increase in ostracod $^{87}Sr/^{86}Sr$ across the mid-Pleistocene transition (MPT) highlights a change in catchment weathering patterns induced by increased glaciation and strong seasonality on the plateau, rather than in climate-enhanced weathering intensity, with an increased weathering of $^{87}$Sr-rich minerals potentially induced by marked extensive glaciation and strong seasonality

in the central plateau. Across the MPT, a significant increase in $^{87}Sr/^{86}Sr$ and frequently fluctuating ratios of ostracod Mg/Ca, Sr/Ca and $\delta^{18}O$ are coincident with increases in both Chinese loess grain size and Arabian Sea lithogenic flux. This correlation indicates an increased glaciation and a strong monsoon seasonal contrast over the plateau across the MPT. Both plants and fauna immediately responded to the MPT shift.

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## Climato-hydrogeomorphological fluctuations printed in lacustrine records in Lake Hövsgöl, Mongolia

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Abstract: Lacustrine sediment information (HDP04, HDP08 and HDP09) printed in Lake Hövsgöl, Northern Mongolia and the lake-catchment conditions reveal long- and short-term environmental changes in the lake-catchment system. Changes in fluvial systems between the Holocene and the late Pleistocene have influenced sedimentary conditions. The information suggests that there were often rapid mass inflows (debris flow, turbidity, etc.) from the catchments during the late Pleistocene. The glacial-interglacial cycle is most clearly presented by aridity (water level change): three Milankovitch parameters (precession, obliquity and eccentricity) are detected in long lacustrine information. A deep depression (cold stage comparable to glacial periods), corresponded to insolation minimum, is detected at about the MIS-5d in records, indicating that this region is highly sensitive to solar insolation. Another depression found during the MIS-11 interval, corresponded also to small insolation minimum, shows that the interval was not a simple prolonged interglacial period.

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## Pleistocene terrestrial uplift and valley degradation rate of S. Korea

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Abstract: Korean Peninsula is situated at the peripheral to marginal part of Western Eurasian Plate so that peninsula has received some degree of compression stressed from the Eurasian-Pacific Plate boundary. This paper illustrates some evidences found from the excavation sites, particularly from the upper Pleistocene sedimentary records formed since the Last Interglacial periods. The geomorphic records in coastal terrace system in the eastern part of Korea has been well documented by mapping shoreline angles along the coasts, which reveals the uplift rate assumed 0.13~0.40 $mm{\cdot}a^{-1}$ in general, even though it shows 0.1~1.4 $mm{\cdot}a^{-1}$ in exceptional point data. The general rate is smaller than that of Japan Island Arc and those of other western Pacific margins where uplift rates are as high as 1~2 $mm{\cdot}a^{-1}$. However it is significant that the rate is much increasing in modern GIA monitoring data in Korea. As the denudation rate of fluvial drainage basin in Korea since last 300 ka, base level lowering is computed as large as 0.14~0.25 $mm{\cdot}a^{-1}$ as shown in Jiri mountain and Donggang area. This implies that both Paleoshoreline angles and valley degradation shifted approximately at the same rate in Korea. This means terrestrial uplifting plays an important role on both coastal geomorphic process and valley degradation system. In Korea traditional glacial/interglacial climatic fluvial terrace formation, responding to both extraglacial excessive valley cutting regime and subtropical pedological geomorphic process as end-member, may be locally deviated by exceptional differential uplift.
Key words: Pleistocene uplift; valley degradation; last interglacial; coastal terrace; fluvial terrace

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## Chronology and sedimentation rate of Eurimji Lake in Jaecheon County of Korea

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Abstract: Eurimji Lake is located at the upstream valley and the lake sediments were initiated by the formation of

by both natural levee and historical embankment. Based on sediment cores of representative boreholes, the lake sediments formed at latest 2000 a BP. It is also one of the oldest artificial reservoirs in the Korean history. A major construction of embankment was carried out at the about AD 800 during the Unified Silla Dynasty. The evidence materials found in the bank are composed of woods and gray organic muds, as well as burned clays pasted on the outer and inner walls of embankment. The origin of bank materials is lake bottom sediments. The lake bottom sediments formed older than 1200 a BP, showing a stable sedimentation pattern in the age interval of 1910 a BP and 1410 a BP. A sedimentation rate of the same interval is about 4 $mm \cdot a^{-1}$, which is relatively high compared to sedimentation regime of other paleo-lakes in Korea. This may be caused by catchment condition which is typified relatively by a strong runoff during the typhoon or stormy season annually. Lastly it is presumed that untill the AD 6th century (Roman period) a paleohydrological system in middle Korean peninsula maintained annually stable even under the steep gradient of catchment landscape and surface processes.
Key words: Eurimji Lake; lake sediment; embankment; sedimentation rate; catchment condition

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## Frequency dependence of AC magnetic susceptibility over a wide range of frequencies: A new rock magnetic proxy for environmental studies

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Abstract: A new measurement system has been developed for detecting frequency dependence of low-field alternating current (AC) magnetic susceptibility in natural samples. Instead of employing intricate AC bridge circuits, this system configuration is simple and consists of a set of primary, secondary (pick-up), and compensation coils, a function generator, and a two-phase lock-in amplifier. This system can measure both in-phase and out-of-phase components of AC susceptibility. The operating frequency can be chosen at any value between 1 Hz and 2.5 kHz, and the AC magnetic field intensity is changeable up to 1 $kA \cdot m^{-1}$. The resolution for the entire frequency range is almost the same as that of the Bartington Instruments susceptometer. Preliminary measurements were made on natural materials, including Chinese loess and paleosol samples, which indicate stronger frequency dependence for the paleosol than for the loess over the entire frequency range. This result suggests that the frequency dependence spectrum over wide band of frequencies can be useful, especially in environmental magnetism, as a new rock magnetic property to estimate the grain-size distribution of superparamagnetic particles and further to quantify the degree of pedogenesis of eolian deposits.

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## The high stands in Qinghai Lake in the northeastern Tibetan Plateau and the implications for global climate models

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Abstract: Closed-basin lake levels in northwestern China during late MIS 3 (40~25 ka) have long been considered much higher than their Holocene counterparts, leading to the creation of climate models incorporating a strong East Asian summer monsoon during late MIS 3. The hypothesis claimed that during the late MIS 3 in northwestern China, the temperature was 2~4℃ higher and the precipitation was even 100% higher than at present.

Qinghai Lake, the largest closed-basin lake in China, lies in the northeastern part of the Qinghai-Tibetan Plateau. Controversies exist with respect to the timing of the high lake levels in Qinghai Lake since the last interglaciation. Our recent work identifying and dating (using optically-stimulated luminescence, OSL) the deposits (such as paleoshorelines, lacustrine, loess, ice wedges, fluvial, etc) around Qinghai Lake suggests that the lake histories on which this hypothesis is based must be seriously modified.

Our field investigations revealed that there are only two terraces in Qinghai Lake, instead of four lake terraces previously suggested. The elevation of the first terrace is ~3199—3206 m (~5—13 m above the present lake level), the elevation of the second terrace is ~3219—3260 m (~25—70 m above the present lake level).

Extensive OSL dating results indicate that: 1) The highest shorelines at ~50—70 m above the present lake level occurred during MIS 5; 2) The highest MIS 3 shorelines yet located, dating to early and middle MIS 3, are ~10 m above the present lake level and ~2—4 m above Holocene highstands.

Related work on Qaidam basin lakes and lakes in the Tengger Desert in northwestern China reflect a similar pattern, suggesting the East Asian summer monsoon was only moderately stronger during early MIS 3 than during the

Holocene, and was weaker than at present during later MIS 3. This scenario is much more compatible with estimates of effective precipitation for the region and suggests global climate models built to incorporate and explain high MIS 3 lakes may need to be re-evaluated.

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## Hovsgol Lake level change during the late Quaternary based on trace elements from ostracod shells in the gravity core sediments (HS 5)

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Abstract: Lake Hovsgol is located in high-altitudinal (1660 m) northern Mongolia which is a southern part of the Baikal Rift Zone formed about 2.5~4 Ma. We collected 20 gravity cores in 2004 to 2006 and 4 box cores in 2009. Among them, HS 5 (124 cm) from the depth 210 m, which was obtained at the south central part of lake has been analyzed for trace elements (Mg/Ca, Sr/Ca, and U/Ca) from benthic ostracods (*Cytherissa lacustris* and *Limnocythere inopinata*). In general, ratios of Mg/Ca and Sr/Ca in ostracods indicate salinity and temperature of the lake water they lived, and ratios of U/Ca in ostracods denotes redox environment of the bottom water of the lake. The three values of trace element ratios from both of ostracods show similar trends of variation, i.e., they show high value in the lowest part of the core and decrease toward the upper part of the core from 100 cm depth and then, they show increase again toward the uppermost part of the core from 30 cm depth. This trend is correlated with grain size and a species analysis of the ostracods very well, and especially four ostracods (*Candona lepnevae*, *Cytherissa lacustris*, *Limnocythere inopinata*, *Leucocythere sp.*) from HS 5 show distinctive change with depth through the core. HS 5 represents sediments of the end of Pleistocene based on the analysis of radiocarbon dating. As a result, the lowest part of the core is estimated to be deposited at LGM along the rising of the lake level, and the values of trace elements (Mg/Ca, Sr/Ca and U/Ca) decrease toward the upper part of core, but it is assumed to be accumulated at the interglacial time. In addition, the values of trace elements (Mg/Ca, Sr/Ca and U/Ca) increase again toward the uppermost part of the core, but it indicates the lake level rise. Therefore, mutual work with other cores in future is required to interpret more detail and accurate change of paleoclimate and paleoenviroment.

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## Distribution of recent ostracod species in the Lake Qinghai area in northwestern China and its ecological significance

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Abstract: The occurrence and abundance of different ostracod species are sensitive to changes in environmental factors, especially to the temperature and the salinity of water bodies. Thus, the ostracods can be used as a scale rough measure of temperature and salinity in the analysis and reconstruction of paleoenvironments. In order to interpret the climate-change data using the ecological characteristics of the ostracods from the drill cores in Lake Qinghai, the distribution of Recent ostracods was studied in Lake Qinghai area. A total of 34 species belonging to the Ostracoda class of Crustacea were collected from different bodies of water in the Lake Qinghai area, and the ecological information for Recent ostracod species was studied. Among these 34 species, *Cypris pubera*, *Eucypris dulcifons*, Ilyocypris *sp. 1*, *Ilyocypris sp. 2*, *Fabaeformiscandona caudata*, *Fabaeformiscandona hyalina*, *Herpetocypris reptans*, *Prionocypris gansenensis*, *Potamocypris villosa*, *Potamocypris smaragdina*, *Paralimnocythere compressa* and *Subulacypris sp.* were first reported by us in the Lake Qinghai area. Some of the species identified exhibited cosmopolitan distributions, at least in the Holarctic region, but *P. gansenensis* and *Ilyocypris echinata* appeared to be restricted to the cold regions in northwestern China.

The ecological significance of the primary ostracod species in the Lake Qinghai area was described according to the observations made during our time in the field and according to data from a number of reports. Our results indicate that the species diversity and abundance of ostracods may be related to water salinity in the Lake Qinghai area. The ecological information for ostracods can be used to distinguish different water environments and types based on the characteristics of one species or of an assemblage of several species.

Key words: Ostracoda; salinity; associations; paleolimnology; ecology; Lake Qinghai

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## Forms of the Tibetan Plateau uplift and regional differences of the asian monsoon-arid environmental evolution— A modeling perspective

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Abstract: Cenozoic Tibetan Plateau uplift/growth exerts profound influences on the evolution of the monsoon-arid environmental system over Asia, which has been confirmed for years by plenty of geological records and numerical experiments. Earlier experiments with and without "mountain" and later ideal experiments of phased uplifts indicated that the Tibetan uplift could remarkably intensify the Asian monsoon and inland aridity via its dynamic and thermal effects. However, the uplift history of Tibetan Plateau/Himalayas is not entirely clear at present and previous ideal experiments might neglect the regional differences of the tectonic uplifts and corresponding climatic responses. Recent studies have shed light on the distinct responses of monsoon sub-systems to the uplift of different regions. The uplift of Himalayas likely has more impact on the South Asian monsoon while the uplift of northern Tibetan Plateau tends to be more closely associated with the East Asian monsoon. Hence, in order to understand the tectonic-climate relation in depth, it is an urgent task for us to differentiate responses of South Asian and East Asian monsoon subsystems based on a detailed reconstruction of the Tibetan Plateau uplift history.

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## Testing the causes of synchronous abrupt climate changes in the Asian summer monsoons and the North Atlantic during the last glacial and Holocene

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Abstract: Linkages between the summer monsoons (Indian and East Asian) and temperature conditions in the North Atlantic are well-documented from paleoclimate records. Understanding the reasons for this teleconnection is important for predicting the future behavior of the monsoons, especially as anthropogenic climate change continues to cause significant impacts in high-latitude areas such as the North Atlantic and Arctic. I will review proxy evidence and present modeling results to examine the physical mechanisms of this teleconnection for three past time periods: stadials/interstadials during the last glacial period, the 8.2 ka event and mid-Holocene abrupt climate change around 5.5 ka. First, to test the hypothesis that pulses of freshwater added to the North Atlantic could have led to a remote climate response in Asia during the last glacial, I will show results from an experiment using the National Center for Atmospheric Research (NCAR) coupled Community Climate System Model, version 3. In this experiment with Last Glacial Maximum boundary conditions, a 1 Sverdrup ($1x10^6$ $m^3 \cdot s^{-1}$) freshwater hosing was applied over the North Atlantic between 50°N and 70°N for 100 years. Summer monsoon precipitation decreased 40%, and appeared to be linked more to changes in atmospheric circulation rather than to changes in snow cover or tropical sea surface temperature. Second, I will review the growing proxy evidence for an 8.2 ka event in monsoonal Asia and compare this evidence to results from another CCSM experiment that uses the newest reconstructions of lake and ice sheet meltwater fluxes causing this event. Lastly, I will present a new global synthesis of proxy records from the mid-Holocene and show evidence for a significant abrupt climate change at about 5.5 ka that is characterized by a step-change with increased sea ice in the North Atlantic and decreased monsoon strength. This abrupt event coincides with a short-lived decrease in solar irradiance, and may imply monsoon sensitivity to very small changes in radiative forcing.

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## Late Pleistocene/Early Holocene climate conditions of North Mongolia based on carbon and oxygen stable isotopes of Dood Lake sediments

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Abstract: Lake Dood is a fresh water lake, remnant of a large glacial lake in the Darkhad basin. Northern Mongolia is located at the coordinate of 51°20' N, 99°23'E, in 1538 m a.s.l.. The length of the lake is 7.5 km with mean width 2.4 km (maximum width is 5.6 km). Mean depth of the lake Dood is 4.7 m, but deepest point is 17 m. The total area is about 41.3 $km^2$. The climate of the Darkhad Basin is extremely continental with a mean annual temperature range of 40℃ and a mean annual precipitation of 300~400 mm. Thus, the lake Dood occupies a transition zone between mountain and forest steppe ecosystems to the south and the coniferous forests to the north. Because of its unique geographic location, this region is very sensitive to climate changes and ideal place for paleoclimate investigation.

This paper makes an attempt to reconstruct the paleoclimate changes in Early Holocene and Late Pleistocene based on results of isotope geochemistry analysis of the core 1, obtained from the Lake Dood in North Mongolia, during the Mongolian-Russian joint expedition in summer of 2005.

The core 1 with length of 645 cm was taken from northern part of the lake, at coordinates of 51°24'26.0"N; 99°19' 30.7"E. Water depth is 3.5 m. The cores were cut lengthwise and after lithological description, it had been sub-sampled in 2 cm intervals. The water, organic matter and carbonate contents of sediments were determined by heating the selected 210 samples (approximately 5~10 cm intervals) at 105℃ , 550℃ and 1000℃ , respectively. Stable isotope ratios of carbon and oxygen on bulk carbonate in 160 sediment samples were determined on Finnigan Mat 252 mass spectrometer at Key laboratory of Lanzhou Institute of Geology, Chinese Academy of Sciences. Isotope ratios are reported relative to the Pee Dee Belemnite (PDB) standard for carbon and oxygen isotope measurements on bulk $CO_2$. Plant fragments, wood debris and shells from 11 samples from different horizons of core 1 were dated by using Accelerator Mass Spectrometry at the University of Arizona.

Age model of core is under the discussion at present stage of investigation. Four age dates (8690±45; 9590±55; 9810±45 and 11270±45) from 449 cm, 564 cm, 584 cm and 644 cm depth intervals are apparently inconsistent; so far they have been excluded from age model. The preliminary age/depth interpolation based on the ages from shallow depth intervals and the inferred sedimentation rates (mean sedimentation rate is 0.13 $cm \cdot a^{-1}$) suggest that core covers about 14400 a BP.

The $\delta^{18}O$ values of bulk carbonate in the cores of Lake Dood varies between −18‰ and −12.8‰ and the $\delta^{13}C$ values vary between −8.2‰ and +0.4‰. The general trends of variation of these isotopes parallel to each other. The covariance of $\delta^{13}C$ and $\delta^{18}O$ values of sediments for the investigated time intervals shows that the Lake Dood was closed basin. Contents of organic matter and carbonate are around 0.6%~13.6% and 1.42%~34.9%, respectively.

Thus the Late Pleistocene and Early Holocene sediments of the core consists of 6 distinct sections based on down core variations of both $\delta^{13}C$ and $\delta^{18}O$ values and organic and carbonate contents, which in its turn are quite consistent with its lithological composition.

Section 1 corresponding to the lower sandy and silty clay layers of 625~520 cm intervals can be divided into 3 sub-units, 1-1, 1-2 and 1-3 based on the change of organic and carbonate contents and as well as isotope values. The sub-unit 1-1 characterized by relatively lower content of organic matter (0.8%) and moderate values of heavier $\delta^{13}C_{carb}$ (−2.2‰) and $\delta^{18}O_{carb}$ (−14.7‰). Gradual increase in content of organic matter and decrease of average values of $\delta^{13}C_{carb}$ (−5.5‰) and $\delta^{18}O_{carb}$ (−15.2‰) have been observed in sub-unit 1-2. These observations suggest a dry and shallow water environment for accumulation of sediment in sub-unit 1-1 and while slightly increased precipitation and still dryer and cooler climate for sub-unit 1-2. Sub-init 1-3 at intervals of 550~520 cm is characterized by relatively high values of the $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ than lower sub-unit 1-2. Especially, samples from this unit shows highest value of $\delta^{13}C_{carb}$, averaging −0.8‰. The $\delta^{18}O_{carb}$ values are around −14.4‰. This silty clay layer contains about 5% of organic matter and 4.5% of carbonate in average. Thus, the high values of heavy isotopic ratios indicate the gradual exceed an evaporation over a precipitation leading to low stand due to a dry climate condition. In addition, lower content of organic matter suggests that primary productivity probably was relatively lower. This dry and cold period (section 1) seems to be corresponds to the Oldest Dryas stadial occurred after the Weichselian glaciation in north Europe approximately in 18000~15000 BP (calibrated).

Section 2, at intervals of 520~460 cm (sandy silt) is characterized by relatively lighter $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ values, average of them are 5.4‰, and −15.6‰ respectively, indicating increased lake level due to drop in ratio of an evaporation to a precipitation for this time interval. The relatively higher contents of organic matter (to 7%~8% in average), suggesting increase in primary lake productivity, support this point. Consequently, it leads to conclude that the sediment of section 3 accumulated under the wet and warm climate condition coinciding with Bölling interstadial of the 15000~14000 a BP (14650~14000 a BP) in a result of sharp temperature rise.

Section 3 from 460 to 290 cm, corresponds to the 170 cm thick clayey silt layer. In this section, both of carbon and oxygen stable isotope ratios increase from depth level of 450 cm. The average values of $\delta^{13}C_{carb}$ and of $\delta^{18}O_{carb}$ are −2.3‰ and −15.1‰, correspondingly. The contents of organic matter and carbonate are relatively constant along the section around and they are 5.4% and 4.7%. So far all above proxies seem to suggest that the silty clay of section 3 accumulated under the considerably dryer and colder climate condition accompanied with lowered lake level and primary productivity relatively to the previous period. According to the age model, this abrupt increase in both of isotopic ratios may be resulted from the cooling coinciding with Older Dryas event in Europe.

Section 4 is included sediments at intervals of 290~220 cm, where both carbon and oxygen stable isotope ratios drastically drop. Mean values of $\delta^{13}C$ and $\delta^{18}O$ are −7.0‰ and −16.9‰ respectively. Relatively lighter isotopic ratios (shifts of −5‰ for $\delta^{13}C$ and −2‰ for $\delta^{18}O$) indicate abrupt changes toward wet and warm climate corresponding to the European Alleörd interstadial. During this time interval lake level was high due to decrease of ratio of the

evaporation to the precipitation and also due to ice melting.

Section 5, at intervals of 220~160 cm, both carbon and oxygen stable isotope ratios are not much changed, but decrease in organic matter contents probably shows drop of primary lake productivity in a result of cold climate. Relatively higher content of carbonate is indicating increase in input of terrestrial carbonates to the lake. According to the proposed age model this time interval corresponds to the Younger Dryas stadial which is known as cold climate period between 12800 cal a BP and 11500 cal a BP.

Section 6, corresponds to the upper 160 cm is separated into 2 sub-units, 6-1 and 6-2. Section 6-1, from 160 cm to 42 cm consists of silty sediments (more clayey in 160~135 cm, sandy in 135~42 cm).Values of isotopic ratios are slightly fluctuating, but much shifts (mean shift of 0.5%~2‰) in values have not been observed. Nevertheless, quite sharp increases in of organic matter contents up to 8%~10% suggest high primary lake productivity. In accordance with age model the section 6 with above characteristics corresponds to early Holocene warming. Relatively the higher contents of carbonate may be result of increased input due to ice melting water during the early Holocene warm climate. Section 6-2, at intervals of 42~0 cm of the core, lithologically corresponds to the silty clay layer. This layer is characterized by drastic shift of $\delta^{18}O_{carb}$ value, from −16.6‰ to −13.4‰, moderate increase in value of $\delta^{13}C_{carb}$, from −6.8‰ to −4‰ and abrupt drop in carbonate content from 20% to 7%. However, organic matter contents are relatively constant, average is about 6.9%. Synchronous positive shifts both in $\delta^{13}C$ (−3‰) and $\delta^{18}O$ (−2.5‰) values suggest drop in lake level due to dry climate. Moreover, sharp decrease in carbonate contents probably indicate climate cooling which is consistent with above result as well.

Thus, the results on stable isotope studies of sediments show that the obvious negative and positive shifts of them had been triggered by climate changes during the Late Pleistocene/Holocene. But, above mentioned suggestions as equivalent for European paleoclimate events are just preliminary, because the ages available for the current core is fairly inconsistent, we need another dating on bulk carbonate for more clear correlations of those events.

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## Variability in precipitation, temperature and river runoff in West Central Asia during the past ~2000 years

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Abstract: The tributary rivers Amu Darya and Syr Darya contribute major amounts of water to the hydrological budget of the endorheic Aral Sea. Processes controlling the flow of water into rivers in the headwater systems in Tien Shan (Kyrgyzstan) and Pamir (Tajikistan) are therefore most relevant. Lake water mineralization is strongly dependent on river discharge and has been inferred from spectrometrically determined gypsum contents. Comparison of high-resolution mineralization data with other proxies for tracing precipitation in NW China indicate that mineralization over the past ~2000 years in the Aral Sea reflects snow cover variability and glacier extent in Tien Shan and Pamir (at the NW and W edges of the Tibetan Plateau). Snow cover in W Central Asia is preferentially a winter expression controlled by temperature patterns that impact the moisture-loading capacity over N Europe and NW Asia. We observed that the runoff, resulting from warmer winter temperatures in W Central Asia and resulting in a reduction of snow cover, decreased between AD 100—300, AD 1150—1250, AD 1380—1450, AD 1580—1680 and during several low frequency events after AD 1800.

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## Holocene sedimentary records in Inner Continental Asia:Mongolian Plateau and Tibetan Plateau

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Abstract: This study aims to reveal Holocene environmental changes on the bases of the physical and chemical analyses of the sediment core obtained from Lake Khuvsgul in Mongolian Plateau and Lake Siling-co in Tibetan Plateau. Analytical results of the Holocene sedimentary sequence in Borsog Bay of Lake Khuvsgul shows that certain

environmental shifts at about Little Ice Age and 3.5 ka BP; noticeable increases are detected in mineral grain size, whole grain size, mineral content and grain density during the periods when the organic matter content, biogenic silica content and diatom abundance decreased. Bottom sediment in Lake Siling-co indicates a comparatively large fluctuations in hydrological conditions at a water inflow for a short period at about 3000~4000 a BP; and decreases in the water level at about 4000 a BP and 3500 a BP, when mineral fractions and whole sediments return to coarse grains, mineral content increased, and organic matter and biogenic silica decreased. Analytical results suggest the comparatively large hydrological changes in the inner Asia during the Late Holocene with a similar pattern of the humidity and aridity in the both lakes.

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## Late Pleistocene and Holocene environmental changes from sediment records of the Lake Dood (Darhad Basin) in northern Mongolia

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Abstract: The paper presents new results in geochemistry and diatoms analyses of the short sediment cores, obtained in 2005 from the Lake Dood (Darhad Basin). The names, length and locations of cores are as following: Core-1, 613 cm, 51°24'26.0"N, 99°19'30.7"E; Core-2, 380 cm, 50°23'43.4"N, 99°21'33.7"E ; Core-3, 150 cm, 51°24'03.0"N, 99°21'17.07"E . The core samples have been subjected to lithology description, determinations of water contents (WC%), organic matter, total organic carbon (TOC), total nitrogen (TN), C/N and total sulfur (TS) contents with aims of recording paleo-environmental changes in northern Mongolia. Water and organic matter were determined using drying oven and furnace, while total carbon (TC), total nitrogen (TN) and total sulfur (TS) contents were analyzed by Elemental Analyzer (Flash EA112 series CHNS-O). The diatom study shows that the sediments of the Dood Lake contain diatoms belonging to the 24 genus and 50 species.

Generally the lithology of the cores (from bottom to top) consists of alternations of sand, clayey silt, sandy silt and silty clayey units in accordance with visual lithology descriptions. The most full geochemistry analysis have been performed for Core-1 which has several age dating, and in accordance with those data the core covers about 14400 a BP and upper 160 cm sediments belong to the Holocene, while lower part of the core sediments had been accumulated during the late Pleistocene. We here mainly concentrate on problems how the organic geochemistry contents and diatom abundances distribute along the cores, what information can be extracted from them, they are consistent or not with information got from other analysis etc.

The TOC and TN contents in the Core-1 are very changeable from 1.32% to 6.59% and from 0.139% to 0.512%, respectively. Especially wide variation in contents of the TOC and TN revealed for upper 300 cm of sandy silt and silty clayey units in comparison to the lower 300 cm where their contents are relatively uniform and low. From this point of view, for core sediments could be suggested two completely different sedimentation environments, although there are some quite sharp oscillations in contents of the TOC and TN for upper 300 cm. If we assume that the TOC and TN contents indicate biological productivity linked with certain climate and paleo-environmental condition, than at least 4 fluctuations could be recorded for upper 300 cm. They are (from top to bottom) 0~43 cm, 43~160 cm, 160~220 cm and 220~290 cm with average TN and TOC about 0.3% and 3%; 0.4% and 4.8%; 0.3% and 3 %; 0.5% and 5% respectively. For lower part such sharp oscillations have not been observed although at interval of 460~613 cm some increase and decrease in TOC and TN contents are visible. Attempt of the interpretation of these changes in TOC and TN contents with taking account into other proxies data such as TIC, TS and diatom analysis resulted in revealing at least two high stand and two lower stand conditions for the upper 300 cm section of the sediment. High stand condition revealed at intervals of 290~220 cm and 160~43 cm based on the highest concentrations of TOC and TN accompanies with high abundance of fresh water diatom species of *Achnanthes minutissima*, *Cocconeis placentula*, *Cyclotella ocellata* and high of TIC, low of TS contents, while the lower stand conditions at intervals of 0~43 and 160~220 associate with high concentration of TS and salinity indicator species *Amphora veneta*, *Fragilaria construens*, *Fragilaria pinnata*. However the available data in ages are quite complicated, main of them had been determined in reworked detritus organic materials, so far it is difficult to tie to the time. Nevertheless, in accordance with the age model suggested by Naran et al, 160~43 cm intervals of high stand probably belong to the early Holocene, while 290~210 intervals are presenting the one of the transitional events between Holocene and late Pleistocene glacial.

Also we have noted some increase in TOC and TN contents at intervals of 520~445 cm with high contents of TC and TIC. So far the results of geochemistry and diatom parameters are one of quite potential proxies for recording paleo-environmental changes.

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## Productivity cycles in the parallel 1-Ma drill core records from Lake Baikal and Lake Hovsgol and climates of past interglacials

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Abstract: Recent drilling in Lake Hovsgol, NW Mongolia, recovered a sedimentary sequence with a base age of 1 cal Ma from the second-largest lake in the Baikal Rift Zone. Because of the small catchment, Hovsgol basin has elevated sensitivity to regional changes in the effective moisture, as seen from variable drill core lithologies and sediment facies.

Here we discuss the work in progress on the regional Pleistocene paleoclimate synthesis based on the three key sediment sections from the Baikal Rift Zone. The section at Academician Ridge of Lake Baikal (53.7°N, drill cores BDP-96 and BDP-98) represents an area where Pleistocene sedimentation rates remained remarkably stable at ca. (4±2) cm·ka$^{-1}$. Stable depositional setting allowed the development of the robust BDP-96 age model derived from orbital tuning of the cycles of biogenic silica content in sediments, which reflect past changes in diatom productivity. 245 km SW, drill core BDP-99 (52°N) has the best-resolved Baikal palynological record, more representative of regional vegetation than the pollen record of BDP-96. Despite the variable glacial-interglacial sedimentation rates at the BDP-99 site, this record can be closely correlated to BDP-96 using basin-wide diatom biostratigraphy. Some 300 kilometers further southwest, Lake Hovsgol sediment section (HDP-04 drill core, 51°N) consists of calcareous sediments with episodic deposition of carbonate-free diatomaceous layers during the past interglacials. HDP-04 is correlated to the BDP-96 via organic carbon-based productivity indices and the apparent diatom biostratigraphic ties between the basins.

We show the relationship between productivity cycles in Lake Baikal and vegetation changes on land during three last interglacials. Productive diatom flora expanded in the lake at the time of the expansion of conifer forests in the Baikal region: durations of the intervals of high BioSi production (accumulation) match the duration of regional forest phases, as seen in the best-resolved records.We discuss repetitive patterns in the records of total organic carbon (TOC), total nitrogen (TN) and $\delta^{13}C_{org}$ in the parallel Lake Hovsgol in Lake Baikal sedimentary records, which reflect past changes in productivity and in the isotopic composition of the carbon pool of both lakes during the past 1 Ma. We show how productivity proxy signals may be used for distinguishing past glacials and interglacials and for constructing the age model for the HDP-04 sediment section.

Finally, we discuss the results of the first quantitative reconstructions of regional climate during MIS 1, MIS 5e, and MIS 11 based on Lake Baikal palynological records in the context of mid-Pleistocene evolution of global climate and compare these reconstructions with the responses in the productivity proxy records.

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## Carbonate oxygen isotope record from Lake Hovsgol, NW Mongolia, lake level changes and the link to atmospheric circulation changes during the past 25 kyr

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Abstract: Lake Hovsgol at 51°N in NW Mongolia is located in a rift basin with a small confined catchment. This lake serves as a sensitive "water gauge" in a region dominated by westerly atmospheric circulation in summer and by the Siberian (Asiatic) High pressure system in winter. Unlike most lakes in the region, Hovsgol remained relatively deep during the last glacial-interglacial transition, preserving a continuous record of finely-laminated sediments. Unlike in the neighboring Lake Baikal, sediments of Lake Hovsgol from the last glacial-interglacial transition contain both endogenic carbonates and ostracod shells. As a result, these sediments represent the first regional paleoclimate archive suitable for a study of past changes in the oxygen isotope composition of lake waters from $\delta^{18}O$ of carbonates deposited in a stable deepwater lacustrine setting.

Here we present a synthesis of Lake Hovsgol data on changes in lake level, hydrologic budget and carbonate oxygen isotope composition to arrive at a new understanding of changes in westerly atmospheric circulation over continental interior of Asian during the past 25 cal ka. We show that the dramatic lowstand of the lake on the order of ~200 m dates back to 22 cal ka BP, i.e., pre-dates the interval typically recognized as last glacial maximum (LGM). Since this major lowstand event, the lake level was rising more or less steadily with an intermediate lowstand on the order of ~100 m at 16 cal ka BP. This positive trend in the hydrologic balance during deglaciation is consistent with

the mineralogy of endogenic carbonates from X-ray diffraction analysis: the abundance of Mg-calcite and the content of Mg in calcite steadily decreased in Hovsgol sediments since the last glacial.

Stable isotope analysis of carbonates in Lake Hovsgol lowstand facies shows that oxygen isotope ratios of lake water were not controlled by either evaporative enrichment in the closed basin or by the hypothesized input of glacial meltwater. Instead, changes in the composition of atmospheric precipitation appear to be the main control on the $\delta^{18}O$ ratios of lake water. Thus, Lake Hovsgol carbonates for the first time offer regional proxy records for past changes in the amount and composition of westerly atmospheric precipitation. Current radiocarbon age models suggest that certain mismatches may exist between the timing of Lake Hovsgol $\delta^{18}O$ signals of enhanced regional precipitation from warmer air masses and the timing of temperature variations in Greenland and the timing of the rapid changes in SE Asian monsoon. The reconstruction of the hydrologic balance of the basin from sediment lithology and carbonate mineralogy coupled with oxygen isotope records of Lake Hovsgol help better explain the regional history of late Pleistocene glaciation and constrain the source of moisture for the postglacial lake level rise in a number of smaller lake basins in continental Asia.

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## Paleoclimatic and paleoenvironmental evolution inferred by the sediment from Xingkai Lake, northeast China

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Abstract: Xingkai Lake is situated at mid-high latitudes, where the climate is dry and cold in winter due to the regime of the Mongolia High; in summer, however, the climate is rainy and hot owing to the heat-and-moisture-abundant maritime air masses. Located on the border of China and Russia, the lake is the largest freshwater body in NE Asia and has been listed as one of the most important sites for global lake drilling in the pole–equator–pole (PEP) belts project within the context of past global changes (PAGES) project. In our work, lake drilling was first carried out in Xingkai Lake and two 270 cm long parallel sedimentary cores were acquired successfully. Paleoclimatic and paleoenvironmental changes of Xingkai Lake since the 28 ka BP was revealed, based on down-core analysis of pollen, grain size, total organic carbon (TOC) and total nitrogen (TN), organic $\delta^{13}C_{org}$ and $\delta^{15}N_{org}$, diffuse reflectance spectroscopy (redness and brightness) and susceptibility and the synthesis of the above multi-proxy analysis.

It is revealed that high percentages of coarse silt and sand reflected low stands of the lake water as a result of decreased rainfall, increases in fine silt indicated high lake levels due to increased rainfall and high contents of clay reflected lentic sedimentary environment under dry conditions. Averaging at 11.4, the C/N ratios show positive correlations with the TOC values, indicating the organic matters of the lake sediment originated mainly from the watershed of the lake, i.e. from the riverine materials. The negative correlations between the values of TOC and $\delta^{15}N_{org}$ also indicate that the organic matters in sediment came mainly from the advanced vegetation in the catchment. Hence, low $\delta^{15}N_{org}$ values and high TOC values indicate warm and humid climate while high $\delta^{15}N_{org}$ values and low TOC values indicate cold and dry climate under which the organic matters of the lake came mainly from lacustrine planktonics (of course decreases in nutrients input to the lake could have also resulted in reductions in $\delta^{15}N_{org}$ values). In addition, warm and humid climate was also indicated by the high values of redness and low values of brightness, while cold and dry climate was also reflected by the low values of susceptibility and coarse grain sizes.

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## Response of the Asian monsoon evolution to precession forcing in an orbital-scale transient simulation

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Abstract: The Asian monsoon evolution has been significantly influenced by the orbital forcings, especially by the insolation variations induced by precession. From 1980s, many observations and simulations, particularly the recent stalagmite records and long-term transient experiments, have indicated that the precession forcing can result in a quasi-20 ka cycle in the variations of Asian monsoon. However, debates still exist on the mechanism how precession-induced insolation drives the Asian monsoon climate, with a focus on two hypotheses of "zero-phase" and "southern latent heat". The "zero-phase" hypothesis proposes that the evolution of Asian monsoon is dominated by the northern summer insolation and the "southern latent heat" hypothesis also emphasizes the influence of latent heat from southern Indian Ocean associated with southern summer insolation. These hypotheses have been both supported

by some geological evidence, thus, they are eagerly required the examinations of numerical simulations especially the transient ones. Owing to the restriction of computational resources, most of previous paleo-monsoon simulations are "snapshot" or "time-slice", which usually limited to some specific periods. Transient experiments, which can simulate the continuous evolution of climate and provide results directly compared to the geological sequences, will help understand the paleo-monsoon dynamic in depth. In this paper, the results from a 280 ka transient coupled ocean-atmosphere model simulation are analyzed. They indicate that the Asian monsoon precipitation responses well to the precession during the last 280 ka and was nearly in phase with the northern insolation in early summer, partly supporting the "zero-phase" hypothesis. Further, our results also emphasize that choosing the referenced insolation arbitrarily when comparing with geological proxies might lead to the uncertain phase relation lacking of effectual physical mechanisms. Therefore, it is of great importance for the paleo-monsoon "forcing-response" studies to select the valid insolation and clarify the climatic significance of the geological proxies.

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## Warm pool hydrological and terrestrial variability near southern Papua New Guinea over the last 50 ka

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Abstract: Abrupt climate changes such as Dansgaard–Oeschger (D-O) cycles and Heinrich events (HEs) are prevalent during the last glacial cycle and widely documented in Northern Hemisphere (NH) high latitudes. However, in tropical regions and the Southern Hemisphere (SH) far fewer records exist, especially in the western Pacific warm pool (WPWP) area. Here, we present a 50 ka archive of $^{37}$Uk sea surface temperature (SST), planktonic foraminifera oxygen isotopes, and terrestrial input indicators including branched isoprenoid tetraether (BIT) biomarkers, $^{232}$Th activity, and non-biogenic sediment components recorded in core MD052928 from the WPWP (near southern Papua New Guinea, PNG). The planktonic foraminifer oxygen isotopes in the core show millennial-scale changes indicating fresher seawater during the NH cold periods (i.e. Heinrich Events, HEs) and suggesting hydrological changes that are most likely linked to the strength of the boreal winter Asian-Australian monsoon (AAM). Our observations are corroborated by evidence from the same core that indicates increased terrestrial input caused by higher precipitation on land and more river runoff from southern PNG during the cold periods. Consistent with other nearby hydrological records from land, our study indicates persistent millennial-scale hydrological changes within the past 50 ka in the western tropical Pacific and Southeast Asia. The timing of the millennial-scale changes appears to have been determined by the latitudinal displacement of the Intertropical Convergence Zone (ITCZ) that reflects a history of heat transport from the tropics and WPWP.

Key words: sea surface temperature; terrestrial input; Papua New Guinea; Intertropical Convergence Zone

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## Climatic change record of the sediments in Lake Biwa, Japan during the last 1 Ma

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Abstract: Lake Biwa is the largest and oldest lake in Japan. The drilled core in 1982—1983 (1400 m core) has revealed ~900 m lake and terrestrial sediments overlying the basement rock. The age data obtained from fission-track dating and tephra correlation indicated the discontinuity of the sedimentary sequence in present Lake Biwa. Recently, the doubt on discontinuity of the sequence in present Lake Biwa was completely cleared by the reinvestigation of the fission-track ages and tephra identification of Danhara et al (2010). Improvements on fission track timescale have successfully identified the paleomagnetic data from middle Matuyama reversed Epoch including the Jaramillo event, determining time coverage of the Lake Biwa sediment as ~1.5 Ma. A highly linear sediment accumulation rate curve is thus given to the 900 m deep Lake Biwa sediment. This secures the stable sedimentary environment of the basin, and the significance of Lake Biwa sediment as a good record for paleoclimate changes. Lake Biwa is, therefore, an ideal terrestrial site to explore paleoclimate and tectonic history during the past 1 Ma of East Asia.

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## Late Holocene Centennial- to decadal-scale monsoon precipitation variability in semi-humid northern China

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Abstract: We developed a composite oxygen isotopic record of cave calcite for the last 1860 a based on three stalagmites from the Huangye Cave in eastern Gansu Province, northern China. The $^{18}O$ values reflect monsoon precipitation changes, with lower $^{18}O$ values representing higher precipitation and vice versa. Three intervals of high precipitation were identified at AD 138—450, AD 730—1200, and AD 1860—1960. Two intervals of low precipitation occurred at AD 1320—1410 and AD 1530—1860. The reconstructed monsoon precipitation variations correlate well with other records further east in the eastern Yellow River Basin, suggesting synchronous precipitation changes during the late Holocene in the semihumid region of northern China on decadal to centennial scales. Peak periods of warfare in dynastic transition times, such as at AD 391—420, AD 601—630, AD 1111—1140, AD 1351—1380, and AD 1621—1650, correspond to sharp declines in precipitation or temperature in semi-humid northern China, indicating a strong connection between climatic and societal changes. Our study suggests that climatic deterioration in semi-humid northern China has played an important role in Chinese societal evolution.

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## El Niño's sensitivity to past and future climate change

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Abstract: The El Niño-Southern Oscillation (ENSO) phenomenon is the most dominant climate mode on interannual timescales, impacting weather systems around the globe. ENSO variability is distinguished by coherent, large-scale patterns of anomalies in the ocean and atmosphere, including sea surface temperature (SST), thermocline depth, winds, currents, precipitation, and atmospheric pressure. This presentation reviews our current understanding of how ENSO responds to external forcings, such as:

—changes of the continental boundary conditions
—orbitally-induced insolation variations
—massive explosive volcanic eruptions
—century-scale solar irradiance variations
—future greenhouse warming

While ENSO is often regarded as just one statistical mode, a detailed analysis of its dynamics using theoretical models reveals that it is a mixture of distinct physical modes with different underlying mechanisms and different sensitivities to external forcing. Disentangling these "flavors" of ENSO is a pre-requisite towards predicting ENSO's response to past and future climate change. Paleo reconstructions of ENSO from different paleo archives such as corals, high-sedimentation cores, speleothems and tree-rings will play a key role in further constraining the sensitivity of ENSO, as simulated by state of the art climate models.

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## The precise link between East Asian monsoon and Antarctic climates during the last glacial period

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Abstract: The idea of bi-polar seesaw has persisted for nearly two decades, motivating intensive research of models and records to investigate phase relationship of abrupt climate changes between two hemispheres during the ice ages. The current dating uncertainties and geographically-limited coverage of records, however, make it difficulty to reconcile model-data and anchor their exact phase relationship, leading as yet to no consensus on factors that control

the abrupt climate changes through oceanic/atmospheric circulations. Here we present several extensively dated and resolution monsoon records during the last glacial period from three caves in South China, which reinforces the correlation of climatic events between Greenland temperature and East Asian monsoon on centennial-millennial time scales. By allocating variations of atmosphere methane trapped in bi-polar ice cores on the $^{230}$Th dated chronology, we demonstrate that six millennial scale weak monsoon events inversely correlate to, within dating uncertainty, the major warm events at Antarctica between 35~80 ka BP. The synchroneity is further supported by one-to-one assignment of centennial-scale climate variability superimposed on the longer-term trend. Our observation suggests synchronous changes of the subtropical monsoons and bi-polar climates on centennial-millennial scales through strong coupling of intertropical convergence zone (ITCZ) and Atlantic oceanic meridional overturning circulations (AMOC), in support of the classic see-saw hypothesis.

Key words: speleothem; China; millennial-scale variability; phase relationship

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## Late Quaternary paleoenvironments of ancient Lake Mojave — reconstructing the history from stratigraphy, sedimentology, soils, geomorphology and radiocarbon dating plus some modeling on the paleohydrology

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Abstract: Late Quaternary fluctuations of pluvial Lake Mojave are recorded in subsurface, cored lake deposits and shoreline features in the terminal depositional basins (Silver Lake and Soda Lake) of the Mojave River. Lake Mojave was one of two large late Quaternary lakes sustained by the Mojave River with the other being the upstream Lake Manix. Silver Lake Depositional Basin (SiLDB) contains a high resolution stratigraphic sequence due to its shallowness and minimal relief across the pre-lake basin floor. Lake building in SiLDB began at ~22 ka with two major high and persistent lake stands occurring between ~18.4 ka and ~16.6 ka (LMI) and ~13.7 ka and ~11.4 ka (LMII). Overflow from Lake Manix sustained LMI which stabilized at the A-shoreline (elevation 287~288 m). LMII coincided with breaching and draining of Lake Manix, reducing the storage capacity of Lake Mojave, increasing its evaporative surface area, and enhancing overflow from Lake Mojave into Death Valley. This overflow downcut the Lake Mojave outlet spillway between 12 ka and 11 ka, ultimately stabilizing at an elevation of 285.5 m (B-shoreline). The majority of shoreline features currently found around the margins of Silver Lake and Soda Lake date to LMII/B-shoreline, as the shallow lake conditions resulted in erosion of older LMI landforms. SiLDB also experienced alternating periods of intermittent lake conditions and periods of desiccation some during higher stands and more continuous Lake Mojave phases with a significant drying event occurring ~15.5 ka. Total drying of Lake Mojave occurred by ~8.7 ka, with playa conditions dominating the Holocene. Using the history of lake level elevations and a simplified, precipitation-discharge/evaporation model, we infer that the late Pleistocene hydrologic conditions resulting in Lake Mojave overflow at Spillway bay in Silver Lake lie between two sets of conditions: (1) a 50% increase in precipitation in the headwater catchment resulting in annual flood events reaching SiLDB with discharges three times that of the modern extreme flood; or (2) a 100% increase in catchment precipitation with a 50% decrease from modern evaporation combined with annual flood events reaching Afton Canyon with discharges two times that of the modern extreme floods.

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## Holocene intensification of the East Asian summer monsoon: timing and mechanism

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Abstract: The Holocene history of the East Asian summer monsoon is of special importance to constraining the predictions of the precipitation pattern and hydrologic cycle in eastern Asia under the background of global warming in the near future. The timing of intensification of the summer monsoon during the Holocene, however, is still debated due partly to uncertainties of radiocarbon dating of different materials and partly to discontinuities of the sedimentary sequences resulting from changes in the facies. Daihai and Hulun Lakes are located in the modern

northern limit of the summer monsoon and particularly sensitive to changes in the monsoon precipitation. High-resolution, multi-proxy records of the sediment cores recovered in the central part of the lakes document changes in the hydrology and ecology of the lake regions and reveal a detailed process of East Asian summer monsoon variations during the Holocene. During the early Holocene before 8000 cal a BP, arid herbs and shrubs dominated the Daihai Lake basin in company with patches of mixed pine and broadleaved forests, indicating a dry climate. The input of terrestrial organic matter to the lake was decreased, denoting weak surface runoff in the lake catchment. In Hulun Lake, dry steppe prevailed over the lake region, and the pollen-derived mean annual precipitation was low. Low-salinity *D. stevensoni* was abundant, warm-adapted *Ilyocypris spp.* was scarce, and cold-adapted *C. neglecta* and *C. cf. bouae* appeared frequently, denoting fresh but cold waters of the lake. Coming to the middle Holocene after 8000 cal a BP, large-scale covers of mixed coniferous and broadleaved forests were developed in the Daihai Lake basin, marking a humid climate. A greater amount of terrestrial organic matter was transported to the lake, implying intensified surface runoff in the lake catchment. In Hulun Lake, grasses and birch forests expanded, and the mean annual precipitation increased markedly. *Ilyocypris spp.* flourished, and Mg/Ca, Sr/Ca and $\delta^{18}O$ of ostracode-shell carbonates were as low as those during the early Holocene, implying that the lake water was still fresh but became warmer. These data indicate that the East Asian summer monsoon was not intensified until 8000 cal a BP, showing a lag of 3000 cal a behind the maximum summer insolation in the Northern Hemisphere. We suggest that the time lag between the summer monsoon intensification and the maximum summer insolation might result from a stagnant northward retreat of the polar front in the North Pacific Ocean due to the existence of remnant ice sheets in the Northern Hemisphere, which would hamper the northward penetration of the summer monsoon front, thereby suppressing the monsoon precipitation over northern China.

Key words: Daihai Lake; Hulun Lake; sediment cores; East Asian summer monsoon; Holocene.

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## Holocene coastal environmental changes in west coast of the Korean Peninsula inferred from salt marshes in Pyeongtaek wetland, Korea

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Abstract: Pyeongtaek wetland, whose name means "flat swamp", is a wide flat paleo-swamp formed during the early Holocene. The Pyeongtaek wetland is located near the central part of the west coast of the Korean Peninsula, and as it was formed during the early Holocene, this area can be particularly useful for investigating coastal plant community ecological responses to climate change and sea-level fluctuations. In this study, we attempted to reconstruct the Holocene coastal depositional environment of the Pyeongtaek area in response to sea-level changes, based on age-controlled pollen and phytoplanktonic algae records. The East Asian monsoon-controlled coastal area is an open system that experiences an intensive interplay between oceanic and terrestrial processes. The ecological response of sensitive terrestrial ecosystems can provide independent data complementing the almost exclusively marine body of evidence. Therefore, coastal-especially intertidal-ecosystems can provide valuable information on past depositional environmental changes because such systems are very sensitive to environmental changes in the sea–continent interface. From 10400 cal~8000 cal a BP, halophytic Chenopodiaceae pollen and marine dinoflagellates indicate the depositional environment was an intertidal flat. Between 8000 cal and 6000 cal a BP, no marine dinoflagellates and abundant meso- to hypersaline salt marshes of Gramineae, with a later increase of mesosaline marshes of Cyperaceae, indicate a transition from intertidal flat to freshwater swamp. From 6000 cal to 4500 cal a BP, aquatic genera and freshwater algae indicate that the study area completely changed to freshwater swamp. The directional sequence in relative abundance of taxa (maximum percentage of pollen of Chenopodiaceae followed by Gramineae, Cyperaceae, and aquatics) suggests a gradational pattern indicative of marked environmental clines typical of intertidal habitats.

Key words: Salt marshes; coastal environment; Holocene; wetland; Pyeongtaek; Korea

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## Snow cover in the upper Yangtze River basin and its influence on the streamflow of Yangtze River

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Abstract: Quantitatively assessing snow cover is a very difficult task due to strong spatial variability in snow accumulation, especially for regions with complex terrain and sparse surface observation stations. Since the 1970s, satellite retrieved snow/ice data have become available and filled the gaps where surface stations do not exist. However, many satellite remote sensing systems based on visible light and infrared are also limited by daylight availability and cloud cover, which has very high frequencies of occurrence in high latitude and highland regions. In this study, the National Snow and Ice Data Center (NSIDC) snow cover data retrieved from passive microwave remote sensing systems are used to quantify the snowpack within the upper Yangtze River Basin (YRB). The passive microwave remote sensing systems have the advantage of all-time and all-weather operations. Using this dataset, the contributions of snow accumulation to the Yangtze River streamflow at three gauging stations in the upper YRB (Gangtuo, Shigu, and Wanxian) were examined for the period 1978—2002. We found that the snow water equivalent (SWE) in the upper YRB had significant influences on streamflow in the spring season, and its indirect effects showed up in the following summer and fall seasons. In general, the influence of snow accumulation decreased from the headwater toward downstream. Results from this study will shed lights on the influence of snow melt over the Tibetan Plateau on the Yangtze River streamflow under the current and future climatic conditions.

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## Reconstruction of closed-basin lake level and paleoenvironmental conditions for tracking East Asian monsoon changes since MIS 3

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Abstract: The past circulation pattern of the East Asian monsoon differed greatly from that of today when large-scale climate forcing and boundary conditions were enormously different form today. Lake sediments from the region have secreted the paleoenvironmental records that can be used for tracking the past monsoon changes. Most sensitive records in this respect are stored in closed-basin lakes because changes in monsoonal rainfall brought about large fluctuations in lake-level and water chemistry that are readily detectable by applying a multidisciplinary approach. Lake Qinghai is a large, closed-basin lake, lying on the outer margin of the Asian summer monsoon. The reconstruction of lake-level fluctuations and paleoenvironmental change in the past 60 ka is based on results from high-resolution seismic investigation on the subbottom sediment structures and from the multi-proxy investigation on sediment cores. Temperature and effective moisture during the MIS 3 were lower than those of the Holocene, as clearly indicated by the reconstructed paleo-lake size and sediment evidence. The major indication of our record confirms a hemispheric coherence that the MIS 3 environmental conditions were neither fully glacial nor fully interglacial. This is consistent with records from the northern South China Sea, Lake Biwa, as well as the European data-set from the Stage 3 Project. Millennial-scale climate oscillations during the MIS 3 superimposed on the pattern are anticipated to be revealed by the study of cores that were recovered with the GLAD800 coring system with higher sampling resolutions. The deposition of wind-blown loess-like sediments in the nearly desiccated lake manifested a severely cold and arid climate during the LGM, suggesting most intensified winter monsoon activities at that time. A permanent expansion of the lake occurred at ~10 ka $^{14}$C BP and the lake level increased toward the present-day dimension from ~8 ka $^{14}$C BP. The effective moisture of the early Holocene, therefore, was lower than that of the late Holocene. The high-resolution post-glacial proxy record suggests a step-wise pattern of moist penetration toward the outer margin of the summer monsoon, which did not simplistically follow that of the insolation seasonality. Other factors, such as westerly conditions and oceanic forcing, may have played roles in controlling the postglacial monsoon changes.

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## The Mid-Holocene climatic transition and the orbital modulation of the solar insolation

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Abstract: In this study, the dust flux and the content of trace metallic elements (Ti, Ni, and V) in a peat sequence from the Hongyuan Swamp (32°46.7'N, 102°31.0'E) are used to reconstruct variations in the intensity of the winter monsoon during the Holocene. This record, when compared with the summer monsoon proxy from the same core, can help elucidate the phase relationship between these two systems. The proxy-based reconstructions show different patterns of the winter and summer monsoons before and after 5.5 cal ka BP. Generally, two monsoons varied reciprocally before 5.5 cal ka BP; however, after 5.5 cal ka BP, these two systems exhibit synchronous changes.

Moreover, the frequency and amplitude of the variations in these two monsoons are different before and after 5.5 cal ka BP. The rate of changes in the solar insolation during the Holocene matches well with these monsoon records, implying that the Mid-Holocene transition may have resulted from orbital forcing.
Key words: winter and summer monsoons; peat; orbital modulated solar insolation; Mid-Holocene transition

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## Holocene lake level changes of the Gun Nuur based on bio- and geo-chemistry related proxies

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Abstract: Gun Nuur (50°15N, 106°36E, 600 m a.s.l.) is a closed depressing basin situated in the east of the Orhon-Selenga depression with semi-saline to fresh water and flat bottom, an eutrophic water with pH 8, and the maximum of water depth is 5 m. The lake area is 2.5 $km^2$. The lake is closed most of time and almost completely isolated from the Buryn Gol River, the right-hand tributary of the Orhon River. Atmospheric precipitation and ground waters are the main alimentation sources of the lake. We drilled lake core GUN2004-A at Gun Nuur (50°15'39.8"N, 106°36'58"E, 605 m a.s.l, 490 cm water depth) on August, 2004. Lithology characteristic is described as following: 0~90 cm dark grey lake mud; 90~190 cm grey-brown mud; 190~320 cm grey-brown laminated mud, and it is dark grey clay including a lot of mollusks between 260 cm to 270 cm interval; 320~330 cm grey black muddy silt; 330~370 cm black-brown mud; 370~386 cm grey-black mud silt; 386~398 cm dark grey mud; 398~440 cm grey black muddy silt; 440~792cm brown-yellow laminated carbonate mud; 792~816 cm grey black slity mud; 816~835 cm grey black silt to fine sand; 835~870 cm brown-black silt; 870~928 cm grey silt to sand.

The age model is constructed on 39 AMS $^{14}C$ dates. The $^{14}C$ date at the top (surface) of the core Gun2002 indicates that the carbon reservoir effect in the Gun Nuur Lake is about 1200 years with an assumption that this carbon reservoir effect applies to the entire Holocene. Multi-proxies paleoenvironmental reconstruction is used in this core. As the analyzed grain size, TOC, $CaCO_3$-content, $\delta^{13}C$ and $\delta^{18}O$ of bulk carbonate, susceptibility and $\chi_{fd}$, we can conclude that oxygen isotope of bulk carbonate is controlled by the temperature, effective humidity and the water residence time together. By the grain size parameter, we distinguish some aeolian deposition layers since late-glacial this area. By the multi-proxies researching, lake level changes can be known: ~10340 cal a BP, 6680~5890 cal a BP, 4950~4300 cal a BP, 3440~2750 cal a BP these 4 stages were cold and dry periods with low lake level characteristics. 10340~6680 cal a BP, was the highest lake level period. 5890~4950 cal a BP, 4300~3440, 2750~1780 cal a BP were the warm and wet periods with a high lake level. After 1780~ cal a BP, temperature decreased but lake level changed from high to intermediate in the closed lake, $\delta^{13}C$ and $\delta^{18}O$ of bulk carbonate changed heavier and heavier with the long residence time. The climate changed cold and wet since about 1780 cal a BP standing for westerlies-dominate.
Key words: Gun Nuur; bio- and geochemistry proxy; palaeoenvironmental reconstruction; Holocene

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## Middle Miocene vegetation and climate in the central and southern part of Yunnan, China

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Abstract: In order to understand the Neogene vegetation succession and climatic changes in Southwest China, we reconstructed the Middle Miocene vegetation and climate at four localities, which are at different latitudes (24°19'25.3"N / 23°35'10.2"N / 22°27'44.5"N / 21°17'05.9"N) along the SW side of the Ailao Mountains in Yunnan Province. The palynological assemblages obtained from the four localities suggest that the Middle Miocene vegetation there was composed of mixed evergreen and deciduous broad-leaved forests with some coniferous forests growing under subtropical conditions. Based on the palynological data, seven paleoclimatic parameters of the four localities are obtained by applying the method of Co-existence Approach and compared with the modern and the Late Miocene and Late Pliocene climatic parameters in Yunnan. The comparison revealed that: 1) Among the four palynological assemblages, the abundance of angiosperms increase while those of gymnosperms and pteridophytes decrease along the gradient of latitudes from north to south. 2) The mean annual temperature (MAT) and mean coldest monthly temperature (MCMT) were obviously lower in Middle Miocene than today (MAT: 13.2 to 14.6 comp. 17.7 to 21 ℃ ; MCMT: 2.9 comp. 10.9 to 15.2℃ ). It suggests that the Ailao Mountains were not high enough to block the summer monsoon and the winter monsoon. 3) In contrast to the Neogene global cooling, the regional values of the MAT and

MCMT in Yunnan increased and accompanied by a decrease of the difference of temperature between the coldest and warmest months (18.4℃ to 19.1℃ comp. 9.5℃ to 12.3℃ ) since Middle Miocene. This may be linked to a gradual reduction in the strength of the Asian winter monsoon as the Tibetan Plateau was uplifted.

Key words: Palynology; Paleovegetation; Paleoclimate; Middle Miocene; Yunnan; SW China

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## The Palaeoclimate record around 5000 a BP in the Westerlies Bosten Lake, Xinjiang, China

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Abstract: Bosten Lake (86°40'~87°26'E, 41°56'~42°14'N), one of the largest freshwater lakes in the interior of China, is located in the southeastern corner of the Yanqi Basin at the southern piedmont of the Tianshan Mountains, northwestern China. Bosten Lake, about 1000 $km^2$ in area, is the terminal lake of the Kaidu River, the only permanent inflowing river, and is the headwater (i.e., the source) of the Kongqi River. The present average lake level is about 1048 m a.s.l.. and the average depth is about 8 m with a maximum depth of 17 m. The mean annual precipitation is only 68 mm with a mean annual evaporation of ~2000 mm within the low-elevation part of the drainage basin. The water balance of Bosten Lake is primarily controlled by the lake evaporation and inflowing runoff of the Kaidu River that is contributed by snow- and glacier-melt water in high elevations and the precipitation within the entire drainage basin.

A 953 cm core BSTC2000 of Bosten Lake in the southern Xinjiang of northwestern China reconstructed the palaeocliamtic change in detail interval about 6400 cal a BP to 5000 cal a BP based on a chronology supported by 9 AMS $^{14}C$ dates publishes in The Holocene. For the Sr/Ca (as a salinity proxy), $\delta^{18}O$ and $\delta^{13}C$ of bulk sediment carbonate (as a temperature proxy), it is shown that this period was cold but high effective humidity climate intercrossed five warm/low effective humidity stages. The periods of about 6400~5975 a BP, 5725~5400 a BP, 5325~5250 a BP, 5200~5150 a BP, 5080~5025 a BP and 5000~4950 a BP were the cold and high effective humidity. There are fitted well with the moving of glaciers in Xinjiang and Tibet plateau, and have a well remote relationship with Neolithic Culture contabescence around 5000 a BP in the southern part of China also. It's more important to prove and inosculate the pattern of Holocene climatic variations summarized by Denton and Karlen (1973) as the moving of glaciers and pollen records in the south and north semi-sphere. From this Bosten Lake core BSTC2000, we can believe convincingly that there existed a long period of cold climate and influenced deeply the ecosystem in this area. And from the core paleocliamte reconstructed, it is expressed that westerlies style formed since about 6400 a BP in the westerlies Xinjiang at persent.

Key words: Bosten Lake; paleoclimate; 5000 a BP; westerlies; Xinjiang

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## Multi-proxy records of paleoclimate variations over the past 25 ka in China

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Abstract: Since the LGM, the maximum extent of ice sheet in the last glaciation, there existed a series of large amplitude climate events, such as the Heinrich, Younger Dryas and 8200 a cooling event, interbedded with the last deglaciation Bølling-Allerød and Holocene Optimum warm events. Through collecting the related publications, it is possible for us to present the synthesis study on the multi-proxy records over the past 25 ka in China. It clearly shows that besides events mentioned above, there are recently reported LGM warming, Mystery interval in cave study. A ~4 ka cooling event is recorded in both the Southeast and Southwest monsoon proxies. Furthermore, we suggested different climatic variation patterns in the monsoon-arid China. The southwest monsoon significantly started strengthening from about 11~12 ka after Younger Dryas, while southeast monsoon was about 8~10 ka. This Geological evidence supports the modelling results. It is worth mentioning that both the winter and summer monsoon strengthened during LGM (18~20 ka) and how to understand it and the Mystery interval, more records needs to be digged out for further study.

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