Proceedings of the 4th International Symposium of IGCP-476

Monsoon, Tectonics, and Paleoclimate/Paleoceanography in East Asia and its Marginal Seas

September 3-6, 2006, Busan, Korea

Host Organizations

Pusan National University
Korea Institute of Geoscience & Mineral Resources

Sponsor

UNESCO-IGCP

Editors

Jang Jun Bahk and Boo-Keun Khim
Preface

We now faced to the growing interests on the earth environmental change such as increasing population, exhaustion of natural resources, moreover, and environmental problems. The global environmental changes, particularly, during the last several million years have become an important goal of scientific endeavor in a world. Over the last decades, many breakthroughs have been successfully performed by many paleoceanographers to better decipher the sediment records, thanks to the introduction of the henceforth classic high-resolution approach as well as to the discovery of new tools and new tracers. We are conscious, however, that a lot still needs to be done in our living continent and neighboring seas.

The collision of India with Asia and consequent uplift of Himalaya and Tibetan Plateau may be the cause of a strengthening of the Asian monsoon system, resulting in the increase in chemical weathering rate, which was the cause of Cenozoic global cooling through a drawdown of atmospheric pCO$_2$. At the same time, the opening of marginal seas in East Asia as a result of lateral extrusion of continental crust due to Asia-India collision contributed to Cenozoic global cooling through modification of eustatic sea levels, global surface and deepwater circulation patterns, and the global carbon cycle. Thus, the prime objective of IGCP-476 is to evaluate the impact of Asian Cenozoic tectonics on regional to global climate with respect to the evolution of the Asian monsoon in order to test hypotheses of tectonics and climate linkage.

However, we have not yet examined the detail inter-relationship among the climatic and tectonic proxies and not yet known an appropriate scenario in the linkage of climate and oceanography in the East Asia and its marginal seas. The success of a series of IGCP-476 symposiums in Tokyo (2003), Shanghai (2004), and Vladivostok (2005) has confirmed the development and expectation in our subjects and the importance of regions. The 4th international symposium of IGCP-476 is another annual chapter in the forum for discussion and exchange of knowledge for this important event.

Korea Institute of Geoscience & Mineral Resources and Pusan National University are greatly appreciated on the consistent support to the preparation of this symposium. Last not least, Local Organizing Committee wishes to thank numerous persons whose names do not appear here for their dedications and contributions to the success of this symposium.

B.K. Khim and J.J. Bahk
September 2006
Organization

Host Organizations

Pusan National University
Korea Institute of Geoscience & Mineral Resources

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S. Hyun (Korea Ocean Research & Development Institute)
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Program

The 4th International Symposium of IGCP-476

Monsoon, Tectonics, and Paleoclimate/Paleoceanography in East Asia and its Marginal Seas

Sept. 3 (Sun)

19:00-20:00 Business meeting by co-leaders and core members

Sept. 4 (Mon)

09:00-10:00 Registration

10:00-10:20 Opening ceremony
Welcome address by Prof. Inn Se Kim (President of PNU)
Congratulatory speech by Dr. Tai Sup Lee (President of KIGAM)
Logistics from LOC by Prof. Boo-Keun Khim

Session 1: Monsoon and Tectonics: Evolution and Linkage
(chaired by Dr. B.N. Nath)

10:20-11:00 Keynote: A 30 Ma reconstruction of monsoon intensity in South and East Asia; P. Clift (U.K.)

11:00-11:25 Tectonics- climate linkage and rise of the Himalayas; R. Kumar (India)

11:25-11:50 Provenance changes of eolian dust at Lingtai section in the Chinese Loess Plateau during the last 720 kyrs; Y. Isozaki (Japan)

11:50-12:15 Development of East Asian deserts during late Cenozoic and its
possible linkage with uplift of Himalaya-Tibet-Tian Shan; R. Tada (Japan)

12:15-13:40 Lunch

Session 1 (continued) (chaired by Dr. J.J. Bahk)

13:40-14:05 Tectonic control and the orbital forcing on the 3 million year sedimentary record from the Central Indian Basin; B.N. Nath (India)
14:05-14:30 Trend, rhythm and amplitude of the East Asian monsoon variation during the late Pliocene and Pleistocene; Y. Sun (China)
14:30-14:55 Evidences for tectonic activities along the north-western coast of Sri Lanka since Miocene to present; U. de S. Jayawardena (Sri Lanka)

14:55-15:20 Coffee Break

Short presentation of posters (15:20-16:20; 4 min. per poster)
(chaired by Dr. R. Tada)

Poster Session (16:20-17:30)

P1: Preliminary report of the loess-paleosol sections in the northern Mongolia; H. Hasegawa (Japan)
P2: Late Pleistocene and Holocene land and sea environmental changes on the west coast of Bohai Bay; Z. Shang (China)
P3: Tracking the weight change of foraminifer tests in water column: preliminary results to reconstruct the monsoon impact on oceanic geochemical cycle; T. Iri no (Japan)
P4: Long-term seasonal sea-ice history of the northern Japan Sea: ice-rafted debris evidence; K. Ikehara (Japan)
P5: Early Holocene intrusion of warm waters into the Japan Sea through the Tsushima Strait; K. Ikehara (Japan)
P6: Variations of bottom currents in the Ulleung Interplain Gap, East Sea since the Last Glacial Maximum; J.J. Bahk (Korea)

P7: Update of the Korean IODP activities; Y.J. Lee (Korea)

P8: Characteristic occurrence of benthic foraminifer during the warm intervals of late Pleistocene and Holocene in the Japan Sea; T. Ohi (Japan)

P9: Late Quaternary paleoproductivity variation of Korea Plateau in the Ulleung Basin, East Sea (Sea of Japan); Y.H. Park (Korea)

P10: Late Holocene environments of Ilsan, Korea, inferred from palynological and diatom records; S. Yi (Korea)

P11: Holocene sedimentation and sequence stratigraphy of the inner shelf deposits off the Nakdong River, Korea; D.G. Yoo (Korea)

P12: Hanon maar in Jeju Island, Korea: a high-resolution archive of the late Quaternary paleoclimatic and environmental changes; S.H. Yoon (Korea)

P13: Mid- and late-Holocene peat stratigraphy of the Pyengtaek blanket peat bog, Korea: preliminary results; U.H. Nam (Korea)

P14: Atmospheric CO$_2$ consumption in the Three Rivers region in eastern Tibet; H. Noh (Korea)

P15: Chemical weathering in the Hong (Red) River Basin: rates of silicate weathering and their controlling factors; S. Moon (Korea)

18:30-20:30 Welcome reception party hosted by KIGAM

Sept. 5 (Tue)

Session 2: Monsoon and Sediments: Land-Sea Interaction (chaired by Dr. P. Clift)

09:20-10:00 **Keynote**: Hafnium and neodymium isotope systematics in the rivers of eastern Tibet; Y. Huh (Korea)

10:00-10:25 Ultra-high rates of loess sedimentation at Zhengzhou since Stage 7: implication for the Yellow River erosion of the Sanmen Gorge; H. Zheng (China)

10:25-10:50 High resolution late Quaternary paleoceanography revealed by IMAGES cores from the western Pacific; M.T. Chen (Taiwan)
10:50-11:10  Coffee Break

Session 2 (continued) (chaired by Dr. Y. Huh)

11:10-11:35  Paleo-hydrology around Japan reconstructed from sediment cores from the Japan Sea and Pacific side; *T. Irino (Japan)*

11:35-12:10  Extreme climate condition in the East/Japan Sea during the penultimate glaciation; *K.E. Lee (Korea)*

12:10-13:30  Lunch

Session 2 (continued) (Chaired by Dr. H. Zheng)

13:30-13:55  Paleoenvironmental reconstruction of the last 40 kyr of the Okinawa Trough using both marine and terrestrial biomakers; *M. Zhao (China)*

13:55-14:20  Orbital- to millennial-scale changes of East Asian monsoon in the East Sea during the last 190 kyr: evidences from grain size and sediment darkness variations; *J.J. Bahk (Korea)*

14:20-14:45  Paleoeceanographic changes along the western margin of the East/Japan Sea during the late Quaternary glacial-interglacial cycles; *S.I. Nam (Korea)*

14:45-15:00  Coffee Break

Session 2: (continued) (chaired by Dr. M. Zhao)

15:00-15:25  Abrupt SST changes during the MIS 6 and 2 in East Sea (Japan Sea): paleoeceanographic implication; *S. Hyun (Korea)*

15:25-15:50  $\delta^{13}$C and $\delta^{15}$N values of sedimentary organic matter in the East Sea (Sea of Japan): indicator as terrestrial contribution and redox potential
of bottom water; *B.K. Khim (Korea)*

**Session 3: Monsoon and Environment: Past, Present and Future**  
(chaired by Dr. T. Irino)

15:50-16:30  **Keynote:** Monsoon simulations for the past, present and future by a coupled ocean-atmosphere GCM; *A. Kitoh (Japan)*

16:30-16:55  Simulation of the Asian summer monsoon for the mid-Holocene and the Last Glacial Maximum; *S.J. Kim (Korea)*

18:30-20:30  Farewell party hosted by Pusan National University

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**Sept. 6 (Wed)**

09:30-12:00  Workshop

1) Reports from working groups
   i) Tectonics of Himalaya and Tibetan Plateau (*H. Zheng & P. Clift*)
   ii) Monsoon evolution (*R. Tada*)
   iii) Indonesian gateway (*K.Y. Wei & M.T. Chen*)

2) Reports on related activities and potential new activities
   ii) IGCP (*H. Zheng*)
   iii) IMAGES (*M.T. Chen, H. Zheng*)
   iv) Suggestion for new activities

3) About synthesis volume
   i) Possible contents and potential authors
   ii) Schedule and publisher

4) Next meeting
   i) Theme: Synthesis of 5 years activities?
ii) Place: Thailand, India, or Japan?

iii) date?

5) Next phase of IGCP project?

6) A session related to this project during the forthcoming IGC?

12:00-13:30 Lunch
# Table of Contents

**Preface**

**Organization**

**Program**

**Session 1**

**Monsoon and Tectonics: Evolution and Linkage**

[Keynote]

A 30 Ma reconstruction of monsoon intensity in South and East Asia......................... 1


Tectonics - climate linkage and rise of the Himalayas.................................................. 3

R. Kumar

Provenance changes of eolian dust at Lintai section in the Chinese Loess Plateau during the last 720 kyrs............................................................... 5

Y. Isozaki, R. Tada, Y. Sun, K. Nagashima, S. Toyoda and A. Tani

Development of East Asian deserts during late Cenozoic and its possible linkage with uplift of Himalaya-Tibet-Tian Shan .............................................. 6


Tectonic control and the orbital forcing on the 3 million year sedimentary record from the Central Indian Basin ................................................................. 8


Trend, rhythm and amplitude of the East Asian monsoon variation during the late Pliocene and Pleistocene .......................................................... 10

Y. Sun and Z. An

Evidences for tectonic activities along the north-western coast of Sri Lanka since Miocene to present ................................................................. 12

U. de S. Jayawardena
Session 2
Monsoon and Sediments: Land-Sea Interaction

[Keynote]
Hafnium and neodymium isotope systematics in the rivers of eastern Tibet ............ 15
Y. Huh and D.C. Lee

Ultra-high rates of loess sedimentation at Zhengzhou since Stage 7:
Implication for the Yellow River Erosion of the Sanmen Gorge ......................... 17
H. Zheng

High resolution late Quaternary paleoceanography revealed by IMAGES
cores from the western Pacific .................................................................................. 18
M.T. Chen and Taiwan IMAGES Group

Paleo-hydrology around Japan reconstructed from sediment cores from the
Japan Sea and Pacific side ....................................................................................... 19
T. Irino

Extreme climate condition in the East/Japan Sea during the penultimate
 glaciation ................................................................................................................. 20
K.E. Lee, J. Choi and J.J. Bahk

Paleoenvironmental reconstruction of the last 40 kyr of the Okinawa Trough
using both marine and terrestrial biomarkers ....................................................... 21
M. Zhao, Chi-Yue Huang, Chen-Yu Huang and L.F. Wang

Orbital- to millennial-scale changes of East Asian monsoon in the East Sea
during the last 190 kyr: evidences from grain size and sediment darkness
variations .................................................................................................................. 22
J.J. Bahk, S.W. Chang and J.H. Jin

Paleoceanographic changes along the western margin of the East/Japan Sea
during the late Quaternary glacial-interglacial cycles ........................................ 23
S.I. Nam, J.J. Bahk and J.H. Jin

Abrupt SST changes during the MIS 6 and 2 in East Sea (Japan Sea):
paleoceanographic implication ............................................................................. 25

xi
δ¹³C and δ¹⁵N values of sedimentary organic matter in the East Sea (Sea of Japan): indicator as terrestrial contribution and redox potential of bottom water ........................................................................................................................................... 26

Session 3
Monsoon and Environment: Past, Present and Future

[Keynote]
Monsoon simulations for the past, present and future by a coupled ocean-atmosphere GCM ........................................................................................................................................... 27
A. Kitoh

Simulation of the Asian summer monsoon for the mid-Holocene and the Last Glacial Maximum ........................................................................................................................................... 29
S.J. Kim, T.J. Crowley, B.Y. Lee and B.C. Suk

Poster Session

Preliminary report of the loess-paleosol sections in the northern Mongolia........... 33
H. Hasegawa, D. Badamgarav, N. Ichinnorov, Y. Khand and R. Tada

Late Pleistocene and Holocene land and sea environmental changes on the west coast of Bohai Bay ........................................................................................................................................... 35
Z. Shang, H. Wang, Y. Pei, C. Fan, F. Wang, L. Tian, Z. Liu and J. Che

Tracking the weight change of foraminifer tests in water column: preliminary results to reconstruct the monsoon impact on oceanic geochemical cycle ........................................................................................................................................... 38
T. Irino, H. Ota and T. Oba

Long-term seasonal sea-ice history of the northern Japan Sea: ice-rafted debris evidence ........................................................................................................................................... 39
K. Ikehara, Y. Kido, T. Irino, Y. Sun and R. Tada

Early Holocene intrusion of warm waters into the Japan Sea through the Tsushima Strait ........................................................................................................................................... 40
K. Ikehara, T. Itaki and H. Takata
Variations of bottom currents in the Ulleung Interplain Gap, East Sea since the Last Glacial Maximum ..........................................................42
J.J. Bahk, B.K. Khim, Y.H. Park and J.H. Jin

Update of the Korean IODP activities ..................................................44
Y.J. Lee

Characteristic occurrence of benthic foraminifer during the warm intervals of late Pleistocene and Holocene in the Japan Sea.................................45
T. Ohi, T. Itaki and S. Hasegawa

Late Quaternary paleoproductivity variation of Korea Plateau in the Ulleung Basin, East Sea (Sea of Japan) ...............................................................47

Late Holocene environments of Ilsan, Korea, inferred from palynological and diatom records .................................................................48
S. Yi, J.Y. Kim, E. Ryu and D.Y. Yang

Holocene sedimentation and sequence stratigraphy of the inner shelf deposits off the Nakdong River, Korea .........................................................50
D.G. Yoo, S.I. Nam, S.P. Kim and Y.K. Kwon

Hanon maar in Jeju Island, Korea: a high-resolution archive of the late Quaternary paleoclimatic and environmental changes ..................................52
S.H. Yoon, S.H. Lee and H.I. Yoon

Mid- and late-Holocene peat stratigraphy of the Pyengtaek blanket peat bog, Korea: preliminary results .........................................................53

Atmospheric CO$_2$ consumption in the Three Rivers region in eastern Tibet ..........55
H. Noh and Y. Huh

Chemical weathering in the Hong (Red) River basin: rates of silicate weathering and their controlling factors ......................................................56
S. Moon and Y. Huh

List of participants ...............................................................................57
Session 1

Monsoon and Tectonics: Evolution and Linkage
A 30 Ma reconstruction of monsoon intensity in South and East Asia

P. Clift\textsuperscript{1,2,*}, L. Giosan\textsuperscript{3}, S. Zhen\textsuperscript{2}, D. Heslop\textsuperscript{4}, J. Blusztajn\textsuperscript{3}, A. Schwab\textsuperscript{1}, A. Tabrez\textsuperscript{5}, Z. Di\textsuperscript{2}, G. Calves\textsuperscript{1}, H.V. Long\textsuperscript{1}

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The sediment delivered by the great rivers of Asia forms the largest sediment bodies on Earth, preserved in the deltas and fans in the marginal seas of South and East Asia. These sediment records can be used to reconstruct erosion onshore and understand how the patterns of drainage have changed through time, as the Asian monsoon strengthened and the Tibetan plateau was uplifted. Isotope data from offshore Pakistan shows that the Indus river experienced major reorganization after 5 Ma, probably driven by uplift of the Salt Range in the frontal ranges of the NW Himalaya. Now new isotopic data from the Red River delta indicate that major drainage capture there occurred before 24 Ma. In turn this suggests the start of topographic uplift in eastern Tibet before that time. The proposed loss of the middle Yangtze from the ancestral Red River before 24 Ma indicates that the regional gradient of eastern Asia had changed in the Oligocene, although major topographic uplift in the region of the modern Red River basin is still believed to be much younger, based on gorge incision ages from SW China and northern Vietnam. Palaeogene topographic change is consistent with stable isotope and palaeobotanical data from Tibet indicating that regional uplift of the central plateau was advanced by the end of the Oligocene. Weathering records from the South China Sea show the onset of rains and intense weathering conditions prior to around 24 Ma. Data from the Pearl River offshore region support an early onset to the monsoon close to the Miocene-Oligocene boundary, followed by drying of the environment after 17 Ma. This is a curious time to see drying because sediment flux from Asia to the oceans remains high until 11 Ma after which it rapidly decreases. Generally periods of high clastic run-off correlate with times of high monsoon summer precipitation. It is not clear whether this discrepancy is real or if it reflects poor age controls on the offshore sedimentary sequences.

The precise age of initial monsoon intensification is not well defined because the long-term records do not yet exist and indeed are limited by the rifting age of the South China Sea and other eastern Asian margin basins. The East Asian monsoon appears to have strengthened after 9 Ma and again at 5 Ma,
probably in response to global climate change events rather than tectonic forcing linked to Tibet. Sediment budgets based on combined seismic and well data from East and South Asia point to a broad positive correlation between monsoon intensity and rates of continental erosion, although the timing is less well defined in the Middle to Late Miocene. A positive correlation between summer monsoon strength and clastic flux/erosion is supported by new work on short Holocene timescales from the Indus delta system that indicates erosion in this drainage increasing sharply after the LGM as the SW monsoon intensified. The greatest erosion was and continues to be focused on the Lesser Himalaya where the modern monsoon precipitation is heaviest. Monsoon rain even appears to be focusing the development of modern thrust faulting through unloading of the frontal ranges. Conversely, erosion of the eastern Tibetan Plateau within the Mekong and Red River basins favours erosion being strongest not only where precipitation is heavy but also where rock uplift rates are high. Erosion does not appear to be controlled by seismic shaking and does require monsoon rain to occur, yet the highest erosion can be found in the gorges of eastern Tibet where uplift is fast. Further south in Indochina rainfall is the highest in the region but exhumation rates remain low due to tectonic inactivity.

Chart showing variations in colour factors at ODP Site 1148 offshore the South China coast, SE of Hong Kong. Factor analysis exploits the wavelengths of absorption characteristic to certain mineral groups to determine bands distinctive of stronger or weaker chemical weathering. Generally more clay minerals and less hematite and goethite is consistent with a wetter, more monsoon climate. Analysis performed by D. Heslop, Univ. Bremen, Germany.
Tectonics – climate linkage and rise of the Himalayas

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Current research in palaeoclimate is focused on the interdependence of tectonics and climate. Tectonic processes bring about a change in distribution of land and ocean that leads to changes in the oceanic circulation patterns. Uplift of many mountains around the globe seems to have been responsible for climatic deterioration during Late Cenozoic. Erosion rates can be modified either in Increase in elevation due to tectonic uplifts or an increase in seasonal rainfall that affects the uplift rates. Reconstructing uplift chronology of large continental areas is, thus, important for understanding the interdependence of tectonics and climate.

Morphotectonic evolution of the Himalayas is seen as a response to the compressive forces in the convergent zones. The critical wedge model, which is applicable for the convergent zones, emphasizes the importance of near horizontal detachments within the crust. Deformations at various levels in the Himalayas had progressed in dissimilar ways. Convergence resulted in the formation of crustal wedge in front of the advancing deformed zones. Foothill basins were formed in the south of the accretionary wedge as the materials were scrapped off the subducting Indian Plate in the hinterland.

Rise of the Himalayas and Tibet was triggered by India – Asia collision along the Indus – Tsangpo Suture Zone (ITSZ) during Early Palaeogene (53 Ma to 47 Ma BP). Subduction along this suture was apparently blocked around 45 Ma BP that led to the transfer of the plate motion initially to the Main Central Thrust (MCT) in the Higher Himalayas, and subsequently to the Main Boundary Fault (MBF) at the edge of the Lesser Himalayas. The Himalayan Frontal Fault (HFF) that forms the southern boundary of the Sub-Himalayas has been inferred primarily on its geomorphic expressions. These three major thrusts, MCT, MBT and HFF, are envisaged to splay off the Main Himalayan Thrust (MHT) that is regarded to form the current boundary of the Indian Plate.

Post-collision deformation in the Himalayas has given rise to the development of several thrust sheets. Continental convergence has also led to the re-activation of the Precambrian basement in the Central Crystalline Zone (CCZ) that is marked by metamorphism and emplacement of granites at deeper levels during Early – Middle Miocene. The Precambrian crystalline rocks that show overprinting of Miocene high temperature events were tectonically extruded along the MCT and other subsidiary south-vergent thrusts during Late Miocene.

The crystalline thrusts sheets originating from CCZ override a predominantly Late Precambrian sedimentary sequence of the Lesser Himalayas that is overlain by Palaeogene marine and continental sediments. The Palaeogene succession consists of a Late Palaeocene – Eocene marine sequence at the
base that is overlain by continental formations. The Palaeogene sequences were deposited on the eroded surface of Late Precambrian sedimentary sequences. Though the surface of unconformity is at places marked by the presence of lateritic rocks, the contacts do not show any appreciable angular discordance. Both, the Late Precambrian and Palaeogene sequences have together undergone intense tectonic deformation during Late Miocene and subsequent tectonic phases.

The first stage of uplift in the Himalayas coincided with the transfer of tectonic deformation from ITSZ to MCT that is marked by the withdrawal of the marine conditions from the Tethyan and Higher Himalayan regions followed by short lived marine transgression in some parts of the Lesser Himalayas. Subsequent phases of uplift coincided with activation of south vergent thrusting first along the MCT and subsequently along MBT. The MBT marks the northern boundary of the Sub-Himalayan foredeep that has been the site of the deposition of a thick succession of fluvial and lacustrine sediments during Neogene and Quaternary periods.

Facies analysis of the foredeep sediments (Shiwalik Supergroup) provides an excellent record of the uplift rates in the Himalayas. Whereas the Palaeogene sequences covered a larger aerial extent of the Lesser Himalayas, the foredeep basins were largely fault bounded and were confined to the south of the newly emergent land. A general coarsening of the detritus upward in the Shiwalik sequence indicates a general increase in uplift rates in the Himalayan region during Neogene and Quaternary periods.

The Indian Summer Monsoon is envisaged to have set in at the commencement of the Neogene when the uplift rates in the Himalayas gained momentum. Piling of the thrust sheets in the Higher and Lesser Himalayas is considered to be the primary cause of the uplift under the influence of isostatic rebound of thickened lithosphere. This would have caused the initiation of the monsoon. Increased precipitation lead to faster rates of erosion that in turn also caused renewed phases of uplifts and consequent repeated phases of the intensening of the monsoon. It has also been demonstrated that the closing phases of the Late Pleistocene Glacial Epoch triggered active tectonics that bringing about changes in the orographic characters and consequently the microclimates. Wetter climates seem to have preceded the cold and arid climate in the north of the high peaks at the time when the high peaks were at relatively lower altitudes.
Provenance changes of eolian dust at Lingtai section in the Chinese Loess Plateau during the last 720 kyrs

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Eolian dust deposited in the Chinese Loess Plateau [CLP] is considered as derived from the dry and semi-dry areas of the western to central China and Mongolia-western Siberia. These eolian sediments are major component of Quaternary loess-paleosoil sequence and late Tertiary Red Clay formation, and provide continuous archives of continental climate change spanning the last 22 Ma (Guo et al., 2002). It is generally considered that the provenance as well as the transport dynamics of these eolian sediments exhibit large-scale fluctuations at tectonic timescales during the late Cenozoic. However, the timing of the provenance change and their potential links to the tectonic events in East Asia as well as global climatic events remain unclear.

We examined provenance of loess in Lingtai section of the Chinese Loess Plateau since 7.2 Ma. We analyzed 35 loess, 33 paleosol, and 33 red clay samples which we separated into two size fractions, fine(0-30 μm), and coarse(>30 μm), respectively, and measured their ESR (Electron Spin Resonance) signal intensity, Crystallinity Index, and contents of quartz. With these three parameters, we can identify temporal changes in the provenance of fine and coarse quartz in eolian sediments in Lingtai section by comparing these parameters with those of present desert deposits in East Asia.

The result suggests that fine and coarse fractions of eolian sediments at Lingtai section have different provenance, and provenance changes in the two fractions occurred at 5.0, 3.6, 2.4, 1.1, and 0.3 Ma. As for the provenance of fine fraction, it is mainly supplied from central and northwest China curing 7.2 Ma. However the contribution from Taklamakan desert increased since 1.1 Ma. While the coarse fraction, change from Siberia to western and/or central China, gradually since 7.2 Ma. The provenance changes a each fractions are associated with glacial-interglacial cycles as well as long-term trends. It is believed that these provenance changes will provide important clues to resolve the evolution of East Asia monsoon, Asian interior aridity and development of western deserts and their relation with a glacial-interglacial cycles and uplift of Himalayas-Tibetan Plateau.
Development of East Asian deserts during late Cenozoic and its possible linkage with uplift of Himalaya-Tibet-Tian Shan

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According to the results of climatic model simulations, formation of inland desert in East and Central Asia could be closely associated with uplift of Himalaya and Tibet. Such desert formation should also be closely associated with evolution of Asian monsoon. In paleoclimate studies, desert sand and loess deposits are generally used to reconstruct distribution of arid areas. Although there is no doubt that deposition of desert sand and loess deposits occurred under arid to semi-arid climate condition, their deposition is also controlled by availability of source material and transport wind system.

There is one school of thought that production of fine-grained clastic materials by the uplift and erosion of Tibet (and Tian Shan) and their transport by westerly winds could be the main cause of deposition of desert sand and loess in East Asia, whereas there is another school of thought that production of clastic materials by mountain glaciers in Siberia and their transportation by northerly winter monsoon wind could be more important. However, no consensus is reached so far. Thus, it is important to examine and specify the source (provenance) of these deposits and reconstruct their changes with time.

Recently, our group introduced a new method to estimate provenance of aeolian deposits that used combination of two parameters; ESR signal intensity and crystallinity of quartz (Nagashima et al., 2006 submitted). This method effectively discriminates fine-grained quartz from different deserts in East Asia (Sun et al., in preparation). We applied this method to Red Clay Formation and loess paleosol sequence at Lihgtai in southern Chinese Loess Plateau area, and compared the obtained data with that of present desert samples in East Asia (Isozaki et al., in preparation). The result suggests that the major source was probably located in areas to the north or northwest of Chinese Loess Plateau between 7.2 and 5 Ma, which shifted toward Taklimakan desert with two steps at 5 Ma and 1.1 Ma (Isozaki et al, in preparation). This is consistent with initiation of Taklimakan Desert formation approximately at 5 Ma suggested by occurrence of loess-like yellow siltstone intercalation with in Pliocene Artux Formation reported by Zheng et al. (2003; 2006 in press) and appearance of desert sand in borehole at central Taklimakan approximately at 1.1 Ma (Sun, 2002).

Formation of Taklimakan Desert could be closely related with uplift of Northern Tibet and Tian
Shan. There is increasing evidence that uplifts of Western Himalaya, Northern Tibet, and Tian Shan occurred and/or accelerated during Plio-Pleistocene (since ca. 5 Ma). These uplifts may influence formation of Taklimakan Desert with two respects. One is by shut down the moisture coming from southwest and enhanced aridity in the area, and the other is by increasing the supply of detrital material from Tibet and Tian Shan that will serve as a source material of desert sand and loess.

To study the fluvial and aeolian deposits covering the last >5 Ma together from view points of provenance and chemical weathering intensity at the same locality within Tarim Basin (Taklimakan Desert area) is the only way to test this linkage. We already started such efforts from this summer and plan to expand the target to Miocene sediments in the near future. We also plan to compare the provenance changes observed in Tarim Basin with that of Chinese Loess Plateau, Japan Sea, and North Central Pacific in the future. Such efforts will solve whether uplift of Western Himalaya, Northern Tibet, and Tian Shan played a fundamental role to form deserts in inland East Asia and enhance Asian monsoon during late Cenozoic.
Tectonic control and the orbital forcing on the 3 million year sedimentary record from the Central Indian Basin

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The Bengal fan is floored by Himalayan pre- and post-collision controlled source sedimentary sequences of the order of 6–7 km at around 13ºN and decreases to 2–3 km at the distal fan. Himalayan Rivers are the major source of sediment supply to the Bay of Bengal. The Central Indian Basin located south of the Bengal fan is bound in the north by an intense deformation zone. Therefore, the sediment facies gradually changes from terrigenous to pelagic type. Also, sediments in the central and southern parts of the Basin are ablated away from the active turbiditic channels, so processes such as pelagic sedimentation and bottom circulation influenced by topographic variation dominate over the delivery from the Himalayan erosional events.

Three sediment cores collected in a north-south transect from the Central Indian Basin have recovered sedimentary records ranging from 500 kyr to 3 Myr. One sedimentary record (Core-AAS2/6, water depth: 4888 m) to the south of an active feeding channel of turbiditic currents from the Bengal fan, in the equatorial region (2°30′S and 80°E) has allowed us to interpret major Himalayan erosional events dating back to 0.5 and 0.8 Myr, (Nath et.al., 2005) both the events synchronous with the results obtained from drilling in the northern areas (ODP legs 116 and 121). A second sediment core (Core-AAS2/3 at 7°48′S, 80°E, water depth: 5463 m) to the south of AAS2/6 has retrieved a continuous sedimentary record of ~500 kyr. While the biological productivity (radiolarian assemblages, organic carbon and biogenic opal) has varied at 41, 23 and 19 ky periodicities which are typical of south Asian monsoon system (synchronous with insolation changes at 65ºN), variation in the lithogenic fraction was influenced mainly by obliquity forcing (~41 and 31 kyr). Variable orbital frequencies for the water column and sediment transport processes could be due to the bottom focusing mechanism. ²³⁰Thexcess analyses of the sediments have shown a large inventory over what can be predicted from the water column scavenging suggesting the role of bottom transport in addition to the wind transported fine-grained lithogenic sediment flux.

The third core measuring 7.5 m (water depth: 5380 m –at 8°58′S; 77°07′E) consisted mostly yellowish brown radiolarian-bearing clays except at three sub-surface levels (4.3, 4.8 and 5.6 m) where dark grey coloured, laminated, sticky sediments occur. The core has been dated biostratigraphically and the sediments here cover a period back to ~3.5 Myr. An additional time marker found in this core is the Austrasian microtektite layer corresponding to 0.77 Myr (Prasad and Sudhakar, 1996). The cosmogenic

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isotope $^{10}\text{Be}$ ($t_{1/2} = 1.5 \text{ Ma}$) has been analyzed in several sections of the core and the depth versus $^{10}\text{Be}$ concentrations indicate a linear decay. Estimated age from the decay constant of $^{10}\text{Be}$ agrees excellently with biostratigraphy. Sediment textural analyses have shown that the clay-sized material is dominant (60-80%) over silt and sand sized material. Clay-sized material mostly constitutes the clastic component and its increased contents are noticed roughly at a periodicity of 100 kyr, prominently between 0.8 and 1.5 Ma BP. Principal clay minerals in the core are illite (I), smectite (S), kaolinite (K) and chlorite (Ch). While downcore trends of I and K+Ch are similar, S distribution is independent, indicating that I, K and Ch are mainly brought in by Himalayan rivers and S is derived from weathering of local basinal volcanic rocks. Elevated I and K+Ch contents noticed at a rough frequency of 100 kyr are indicative of increased detrital deposition during orbital eccentricity periods, and may either be due to glacial-interglacial variation or monsoonal intensification at these time scales. Incidentally, paleo-SST (sea surface temperature) variation estimated from transfer function equations also reveals synchronous cyclicity corresponding to Earth’s orbital eccentricity cycles (Gupta et.al., 1996). A significant increase in sand-sized material is found at depths corresponding to 0.8 to 1.1 Myr and coincides with an increase in TOC (total organic carbon) content, which suggests a high biological productivity in the surface waters coinciding with climatic transition during mid-Pleistocene. Three dark-gray layer sediments, corresponding to 1.3, 1.75 and 2.3 Myr, contain negligible sand-sized fraction (<0.1%), low TOC and are devoid of biogenic skeletons, but rich in smectite (~57%) and contain volcanoclastic material such as pumice. Further, these layers are also distinct in geotechnical and physical properties with rather high shear strength (12 kPa), plasticity (47%) and wet bulk density, but lower water content and porosity (Khadge, 1997). Coincident with these physical properties is the presence of clay minerals in these layers with higher crystallinity indicating a proximal source. The core also shows sub-surface peaks of manganese at several depths related to the past redox changes, probably driven by productivity variations in the region.

References
Trend, rhythm and amplitude of the East Asian monsoon variation during the late Pliocene and Pleistocene

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Loess deposits in the Chinese Loess Plateau (CLP), which covers an area of about 500,000 km² with a thickness of 150 to 300 m, provide continuous records of the changing climate in Asia since the late Cenozoic; these records include the history and variability of the East Asian monsoon (EAM) and Asian interior aridity. Analysis of proxy indicators of the EAM (e.g. magnetic susceptibility and grain size) has linked EAM evolution to both external (i.e., solar insolation) and internal (e.g., ice volume change) forcing over the past 2.6 Ma. Here two continuous loess-palaeosol and red-clay sequences in the central CLP were investigated to reconstruct the EAM variation during the late Pliocene and Pleistocene. By applying mean grain size of quartz particles (MGSQ) and magnetic susceptibility (MS) as proxy indicators for the intensity of winter and summer monsoons, respectively, we evaluate the long-term trend and changes in the rhythms and amplitude of the EAM variation over the past 3.6 Ma.

Zhaojiachuan (35°45′N, 107°49′E, 1250 m above sea level, asl) and Lingtai (35°04′N, 107°39′E, 1350 m asl) sections are located in the central CLP, within an area that is highly sensitive to the variations in the relative strengths of the East Asian summer and winter monsoons. Eolian sequences at the two sites are composed of two parts: an upper loess-palaeosol sequence and an underlying Red Clay formation. The pedostratigraphy and magnetostratigraphy of the two sections have been investigated in previous studies. Chronologies for the two sections have been generated by paleomagnetic analyses, and subsequently refined by using orbital tuning method. The good correlation of the MS and MGSQ time series between the two sections suggests that it is reasonable to generate stacked records for the past 3.6 Ma by averaging the normalized MS and MGSQ data of two sections.

By applying low-band filtering, the long-term trend (>500-kyr) of the summer and winter monsoons are separated from the orbital-scale variations. The filtered results indicate that the long-term evolution of the summer monsoon is characterized by a gradual increase over the interval 12.8-3.6 Ma, a long-term decrease between 0.6-2.8 Ma and an evident increase around 0.5 Ma. By contrast, the winter monsoon intensity was relatively stable between 2.9-3.6 Ma, followed by a notable increase over the interval 2.5-2.9 Ma. Since 2.2 Ma, the winter monsoon exhibits a gradual strengthening, coupled with the gradual increase of the north hemisphere ice volume.

Temporal variations of the stacked MS and MGSQ records indicate three large shifts in the EAM variation at about 3.4 Ma, 2.72 Ma and 1.25 Ma, respectively. On this basis, the EAM evolution since the
late Pliocene can be subdivided into three phases: 2.72-3.4 Ma, 1.25-2.72 Ma and 0-1.25 Ma. Each phase is characterized by unique amplitude and frequency characteristics for both summer monsoon and winter monsoon. Spectral analyses of the stacked monsoon proxies reveal a dominant 410-kyr periodicity over the interval 1.2-2.6 Ma and an increased 100-kyr variance after 1.2 Ma, implying a non-linear response of the long-term EAM evolution to orbital and glacial forcing.
Evidences for tectonic activities along the north-western coast of
Sri Lanka since Miocene to present

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The Island of Sri Lanka lies between latitudes 5°55′ and 9°51′ north and longitudes 79°41′ and 81°53′ east, situated 32 kilometers east of the southern tip of India. Sri Lanka is separated from India by a shallow sea. The total land area measures 65,580 square kilometers in extent 430 km in length from north to south and 225 km in width at the broadest part. The length of the coastline open to the sea including bays is 1639 km and the coastline of the other small islands belong to Sri Lanka is about 281 km.

Geologically ninety percent of the country rocks are metamorphic of Precambrian age. A few
igneous intrusive bodies also can be seen within these crystalline formations. The rest ten percent is sedimentary rocks formed during and after the Jurassic (Cooray, 1967). The north, north-west and south east sectors of the coastal belt of Sri Lanka have been subjected to various changes such as sea level rises, land upliftment, erosion, and submergence etc. due to the global activities within last 25 million years. Sedimentary limestone, sandstones, coral reefs, older and younger beach rocks, dune sand deposits, gravel deposits etc., are some of the formations since Miocene to Holocene period.

A number of pre-selected locations were drilled to study the availability of groundwater in these sedimentary formations above the Precambrian basement rocks (Lawrence and Dharmagunawardena, 1981). The borehole data were used to study the subsurface sedimentary formations.

The results show a layer of sandstone has deposited above the Precambrian basement rocks during Miocene and younger limestone layer has formed above the sandstone. Then, while the land is uplifting slowly to the surface the limestone has covered by shallow sand, silt and clay mixed sediments. After the upliftment, the limestone and sandstone layers reached and opened to the atmosphere and then subjected to the surface geological processes. As a result the sandstone bed has been saturated by the infiltration of surface water and typical karst features has been developed in the limestone. Further tectonic movements submerged the limestone and sandstone deposits and a section of the area has gone further down due to a fault type displacement or forming a shear zone. Later the whole area has been covered by the Quaternary sediments. At present the land has uplifted again and most of the areas have been covered by recent sediments. Exposed limestone and karst features also clearly observable.

This correlation from the studies of borehole samples describes the locations of faults and tectonic activities and other environmental changes which have been taken place in this Island since Miocene. At present these formations occur within the land area of the country.

References
Session 2

Monsoon and Sediments: Land-Sea Interaction
Hafnium and neodymium isotope systematics in the rivers of eastern Tibet

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Strontium and osmium isotope ratios in paleo-seawater records have been studied in the hopes of reconstructing the link between climate change, continental weathering, and seawater composition. However, the continental flux to the ocean of Sr and Os isotopes are influenced by non-silicate weathering (carbonates and black shales), and it is a non-trivial task to extract information about past climate change from these records. On the other hand, Hf is primarily in silicate rocks, and the hypothesis is that significant fractionation occurs during weathering, which can be related to the intensity of silicate weathering. Nd on the other hand, does not fractionate significantly during weathering.

Hafnium and neodymium isotope systems are strongly coupled in terrestrial rocks but become decoupled during weathering and transport to the oceans, such that the seawater array has a different slope than the terrestrial array on an $\varepsilon_{Hf}$–$\varepsilon_{Nd}$ plot [1, 2]. In order to understand the sources and processes involved in continental weathering, we investigated the two isotope systematics for the river suspended and bed material of the eastern Tibetan Plateau. Select samples from the Huang He (Yellow), Chang Jiang (Yangtze), Hong (Red), Mekong and Salween were studied.

The Hf and Nd concentrations in the solid were 1-45 ppb and 0.2 – 6 ppm, respectively, and in the dissolved load were 1-84 ppt and 10-390 ppt, respectively. While the Zr/Hf ratio in the suspended load is relatively constant at ~70, in the dissolved load it varies between 20 and 230. Thus, it is difficult to use the dissolved Zr as a proxy for dissolved Hf which occurs in much lower concentrations. The $\varepsilon_{Nd}$ values of all solid samples ranged from -14 to -8. This is more radiogenic than the estimated upper continental crust value of -17 based on major river sediments and wind-blown dust [3]. The $\varepsilon_{Hf}$ values of the solid samples have a large range compared to $\varepsilon_{Nd}$ from -20 to +6, but most fall between -10 and 0. The suspended load is more radiogenic than the silt or sand size fractions of the bed load. The highest values are seen for the suspended load of tributaries draining igneous complexes in the Hong and Mekong river drainages and the lowest values for bed load draining sedimentary rocks in the Hong drainage. However, overall, the suspended load of the five rivers has overlapping $\varepsilon_{Hf}$ and $\varepsilon_{Nd}$ values. On an $\varepsilon_{Hf}$–$\varepsilon_{Nd}$ plot, the river suspended and bed load samples occupy a space between the terrestrial array and the seawater array.
References


Ultra-high rates of loess sedimentation at Zhengzhou since Stage 7: implication for the Yellow River erosion of the Sanmen Gorge

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Mangshan Plateau is located 25 km to the west of Zhengzhou on the south bank of the Yellow River. Here the river flows out through the Sanmen Gorge releasing most of its suspended load following a dramatic decrease in gradient. The stratigraphy of the Mangshan loess deposits, consisting of a number of loess and palaeosol sequences, was established following magnetostratigraphic studies and measurements of magnetic susceptibility and grain size distribution. The Bruhnes/Matuyama boundary was found at the depth of about 130 m, indicating that this sequence at Mangshan resembles what is observed elsewhere in the Loess Plateau.

The upper part of the Mangshan loess displays extremely high sedimentation rate (~ 50 m\(^3\) per 1000 years), lower susceptibility values and coarser grain-size distribution unlike the lower part of the profile and other sections in the Loess Plateau. This striking change indicates that the upper Mangshan loess had a different sediment source, different from deserts that act as a common source for most of the loess deposits in central China. This sediment source is believed to be the proximal Yellow River floodplain, and the ancient alluvial fan lying at the eastern end of the Sanmen Gorge. The age estimation of the formation of the alluvial fan, based on Mangshan loess, suggests that the Yellow River may have eroded the Sanmen Gorge at approximately MIS 7.
High resolution late Quaternary paleoceanography revealed by IMAGES cores from the western Pacific

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New data and hypotheses of western Pacific paleoceanography based on high resolution marine sediment cores have been quickly developed in the past 10 years through active participations to IMAGES program. These IMAGES cores retrieved from the western Pacific (from the Okhotsk Sea to southern Papua margin) provide high quality paleoclimatic archive for better understanding the mechanisms controlling late Quaternary variability in the western Pacific from millennial to orbital and longer time scales. Our science objectives of the IMAGES programs have been particularly focused on reconstructing climate and surface ocean variability expressed in the East and South China Sea (ECS & SCS), and also on developing of new composite SST and terrestrial sediment input with multiple proxy approaches. New calibration data sets for paleo-estimation and new methods of time series analysis techniques, and new spectral models for interpreting the timing and amplitude of western Pacific climate dynamics, are also focuses of our program. Our studies suggest that the climate variability in the western Pacific is mixed with “early warming” and “late warming” response groups. Most early warming responses are clearly observed in our ECS productivity records and at some Terminations of SCS SST variations. On the other hand, ECS and some SCS SST records exhibit “late warming” responses synchronous with the timing of Northern Hemisphere glaciations and East Asian winter monsoon strengths. Our studies indicated that the western Pacific climate variations were characterized by a complex evolution interplayed by monsoon, sea level, and inter-hemispheric interactions on different time and space scales, and at some time intervals, were affected by the ocean conditions over the western Pacific warm pool. Our studies will also bring implications on future planning of IODP proposals of Okinawa Trough and western Pacific warm pool (Papua, Indonesia) scientific drilling.
Paleo-hydrology around Japan reconstructed from sediment cores from the Japan Sea and Pacific side

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East Asian monsoon is one of the largest parts of hydrological cycle on the earth (An, 2000). It is generally considered that inter-hemispheric-scale atmospheric circulation transports water vapor from Indian and Pacific Ocean to Asian continents. Therefore, the intensity of dust event (aridity) in the inland China reconstructed from sediments of the Loess Plateau and the northwestern Pacific Ocean has been utilized as a proxy for monsoon intensity. However, variability in spatial and temporal (seasonal, inter-annual, and longer time-scale) distribution of precipitation is generally difficult to predict because the response of monsoon rain to the variation of other climatic system such as ENSO is very complicated (Zhou et al., 2001).

Although the east Asia is a monsoon region which is generally characterized by hot-humid summer and cold-dry winter, precipitation events in the far-east Asia region such as the Japanese Islands have not been well constrained in time domain because most of studies were conducted on terrestrial records and the ages were not determined as precisely as those for marine sediments. In order to reconstruct the precise timing of precipitation events on the Japanese Islands and clarify the mechanism promoting precipitation there, we analyzed the mass accumulation rate, grain size, and mineral composition of detrital fraction, pollen assemblage, and paleo-SST for a long giant piston core (MD01-2421, 45.82 m length) recovered from 2,224 m water depths on the Pacific side of central Japan during the IMAGES (WEPAMA) cruise in 2001. Sediment age model is based on Oba and others (2006 in press). Detrital mass accumulation rate and pollen monsoon (high precipitation) indices such as Cryptomeria and Sciadopitys abundances are higher during later halves of MIS 1, 5a 5c, and 5d. Agreement of these two kinds of signals strongly suggests that the high precipitation events on Japanese islands promoted the higher river discharge and detrital flux to the marine sediments during the identical periods. These timing of high precipitation events delays by ~10 ky those in China reconstructed from Japan Sea core.

These differences in the timing of maximum precipitation could be attributed to the southward shift and stagnation of frontal zone in summer extreme, which could promote longer rainy season on Japanese islands and less rain in northern central and east China at the same time.
Extreme climate condition in the East/Japan Sea during the penultimate glaciation

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The late Quaternary records of alkenone sea surface temperature (SST) from core located in the central part of the East/Japan Sea showed a severe cooling during the penultimate glaciation. During the period of MIS 6, the alkenone temperatures were low (7-10°C), whereas during the MIS 5e the temperatures increased rapidly up to 21°C. The coretop alkenone SST is 17°C. Variations in SST at this area could be closely related with the supply of warm waters from the Tsushima Warm Current and/or the cold air and wind from the North.
Paleoenvironmental reconstruction of the last 40 kyr of the Okinawa Trough using both marine and terrestrial biomarkers

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The Kuroshio is the dominant surface current in the North Pacific, and it plays an important role in regulating regional and global climate. However, the strength and pathway of the Kuroshio during the late Quaternary are still not well understood. Here we report the UK37 SST and planktonic foraminifera oxygen isotope records of two cores (DGSK9603, CSH-2) drilled from the middle Okinawa Trough and compare them with two published records from the southern and northern Okinawa Trough (ODP1202B, MD982195) to reconstruct the paleoenvironmental conditions of the Okinawa Trough for the last 40 kyr, and to infer the strength and pathway of the Kuroshio during the last glacial. The millennial-scale SST records reveal that the last glacial maximum (LGM) to the Holocene SST differences were about 4°C for all four locations. The south-north SST gradient during the LGM was only slightly larger than that of today. These results indicate that the Kuroshio maintained its flow through the Okinawa Trough during the last 30 kyr, and only weakened slightly during the LGM. The content of alkenones increased during the glacial period reflecting increased marine productivity, probably caused by increases of nutrient input from the terrestrial environments due to low sea level. This inference is also supported by the increased contents of land plant biomarkers (C\textsubscript{27}, C\textsubscript{29} and C\textsubscript{31}, n-alkanes) in the cores during the glacial period.
Orbital- to millennial-scale changes of East Asian monsoon in the East Sea during the last 190 kyr: evidences from grain size and sediment darkness variations

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Sediment darkness values ($L^*$), median diameters of detrital grains ($D_{50}$) were measured in high-resolution on a piston core sediment (05GCRP-21) from the South Korea Plateau, East Sea (Sea of Japan). A preliminary age model for this core sediment was established based on 4 AMS$^{14}$C dates and well-known marker ash layers of AT and Aso-4. Further age control points were provided by correlation of $L^*$ variations with MD01-2407 core sediments with a well-established age model (Kido et al., 2006MS). According to the age model, cyclic variations of the proxies show a significant correlation with orbital- to millennial-scale global climate changes, probably during the last 190 kyr. The variations of $D_{50}$ reveal remarkable similarity with SPECMAP $\delta^{18}O$ curve since the MIS 6, with intervals of finer detrital sediments in the interglacial stages. The variations of $L^*$ also demonstrate a significant correlation with GRIP $\delta^{18}O$ curve, where the dark layers with low $L^*$ appear to be related with DO interstadials of millennial-scale variability. Correlation between the $L^*$ and $D_{50}$ variations show that the dark layers consistently have finer detrital sediments. The relationship between detrital grain size and sediment darkness is generally consistent with the previous findings from the Japan Basin (cores MD01-2407, PC-5), confirming that it is unique and basin-wide in the East Sea. A precise age model of core 05GCRP-21 based on additional independent age controls will make it possible to reconstruct spatial changes of detrital grain size and other proxies between the South Korea Plateau and Japan Basin, which may have been linked with Asian monsoon variability.
Paleoceanographic changes along the western margin of the East/Japan Sea during the late Quaternary glacial-interglacial cycles

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AMS-^{14}C age dating, stable oxygen and carbon isotopes of the planktonic foraminifera *N. pachyderma* sin., and detailed organic-geochemical analyses (e.g., carbon and nitrogen isotopes of organic matters and opal) were carried out on several marine sediment cores recovered from the western margin of the East/Japan Sea. The objective of this study is to reconstruct paleoceanographic changes of the western margin of the East/Japan Sea during the late Quaternary glacial-interglacial cycles. The multi-proxy data obtained from the western margin are compared with those previously published in the central and eastern parts of the East/Japan Sea. In particular, organic-geochemical multi-proxies are used to delineate characteristics and origin of organic matter deposited along the East/Japan Sea western continental margin. Therefore, the results obtained from the western margin may contribute to the understanding of the whole paleoceanographic changes in the East/Japan Sea during the late Quaternary glacial-interglacial cycles.

Variations of the multi-proxy records from the sediment cores revealed the distinct paleoenvironmental changes over the late Quaternary glacial-interglacial cycles. Interglacial periods (MIS 5e and Holocene) are characterized by high contents of organic carbon up to 7%, relatively low C/N ratios (≤ 12) associated with heavy values of δ^{13}C_{org} (≥ -23.5‰) and δ^{15}N (≥ 5‰), and high contents of biogenic opal of 10-22%, reflecting an enhanced productivity in the sub/surface water. In contrast, glacial periods from MIS 5d to MIS 2 reflect relatively increased input of terrigenous organic carbon and reduced productivity, supported by low TOC contents, depleted δ^{13}C_{org} values (≤ -25‰), relatively light values of δ^{15}N (≤ 5‰) and low opal contents. However, there are a couple of peaks with relatively increased supply of marine organic matter during the glacial MIS 3 and 2, probably indicating to some extent enhanced productivity of the surface water during the interstadials. A gradual shift towards heavy δ^{13}C_{org} and δ^{15}N values along with high biogenic opal during the last deglaciation indicates an enhanced primary production within the sub/surface water due to inflow of the Tsushima warm current and increased nutrient supply from the deep water.

In particular, there is absence and/or low content of CaCO_{3} throughout the Holocene and during the last interglacial period, i.e. MIS 5e. During these warm periods, the carbonate dissolution along the relatively shallow western margin of the East/Japan Sea might have been related to high influx of organic matter to the sea floor and to the highly oxygenated cold water mass which was originated from the
northern part of the East/Japan Sea. These combined processes might have accelerated decomposition of organic matter above the sediments, then leading to raising $p\text{CO}_2$ of interface waters above the bottom sediments and subsequently resulting in total and/or strong carbonate dissolution at the sea floor during those time intervals.
Abrupt SST changes during the MIS 6 and 2 in East Sea (Japan Sea): paleoceanographic implication

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Stable oxygen isotope compositions of foraminifera and alkenones variation of a piston core (M04-PC1A) were conducted to elucidate the evolution of paleoceanography of the East Sea (Japan Sea). Paleoenvironmental changes since the last ~ 320 ka were reconstructed based on the oxygen isotope compositions of foraminifera and alkenons data from the deep-sea sediments of the piston core taken from the Korea Plateau in the East Sea (Japan Sea). Oxygen isotopic records of the planktonic foraminifera, that were estimated to be ca. 320 ka in age, show the Marine Isotope Stage (MIS) from 1 to 8. Comparing this result with previously reported stable isotope data in the East Sea as well as the global oxygen isotope trend, it is suggested that paleoceanographic and paleoclimatic changes in the East Sea has been quite different from those of open oceans: it reserves freshwater input signals and steep drop of paleotemperature (about 2 per mil heavier) at the MIS 2.1 and 6.2, respectively. Paleotemperature variations of the surface water in the East Sea were reconstructed using unsaturated longchain alkenones (ULA) along with oxygen isotope data. The result shows that paleotemperatures was about 10°C lower than today’s surface temperature during the MIS 6.2. However, paleotemperature during the MIS 2.2 was characterized by relatively small temperature drop of about 3 °C. Both oxygen isotope and ULA data show the systematic coeval trend throughout the late Quaternary. These data suggesting local oceanographic conditions were more distinctive feature and have prevailed since the MIS 6 in the East Sea.
δ¹³C and δ¹⁵N values of sedimentary organic matter in the East Sea (Sea of Japan): indicator as terrestrial contribution and redox potential of bottom water

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The effect of sea level change in the East Sea (Sea of Japan) is fundamental to the anoxia of bottom water resulting from the stagnant, strongly-stratified water-column with limited ventilation during the glacial periods. Here we present extraordinarily co-varied δ¹³C and δ¹⁵N values of sedimentary organic matter, representing distinct negative anomalies for the thick and thin dark laminated mud layers during the late Quaternary. The most plausible cause to induce such peculiar isotope variations seems to be the anoxic diagenetic condition in the bottom water during the glacial period. The reduction of δ¹³C values may be attributed to the selective preservation of ¹³C-depleted organic compounds and simultaneously the decrease of δ¹⁵N values may be due to bacterial growth adding ¹⁵N-depleted biomass to the residual materials. The anoxic decay of sedimentary organic matter leads to the negative excursion of both isotopes, although the enhanced terrestrial organic detritus during the glacial is an additional contribution.
The 4th International Symposium of IGCP-476

Session 3

Monsoon and Environments: Past, Present and Future
Monsoon simulations for the past, present and future
by a coupled ocean-atmosphere GCM

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First, we show some results from paleoclimate simulations for the Mid-Holocene (6,000 years before present) by coupled climate models under the Paleoclimate Modeling Intercomparison Project (PMIP), which is a project by PAGES/IGBP and CLIVAR/WCRP. The model used is a global coupled ocean-atmosphere general circulation model (AOGCM) developed at the Meteorological Research Institute (MRI-CGCM2). The model simulates enhanced winter-to-summer seasonal change and enhanced monsoons, in response to the prescribed orbital forcing. The characteristics of El Niño/Southern Oscillation (ENSO) (strength, frequency and spatial pattern) vary due to changes in background climate state, suggesting that the impacts of ENSO outside the tropical Pacific are also different from those today. Climate simulations for the Last Glacial Maximum (21,000 years before present) will also be shown. Overall agreement between model simulations and available observed proxy data supports a use of this climate model for further research.

Second, the role of large-scale orography on climate is investigated by a series of experiments. Being different from previous similar experiments, we used an AOGCM (MRI-CGCM2) so that response of the ocean and atmosphere-ocean coupled phenomena can be assessed. We used eight different mountain heights: 0% (no mountain), 20%, 40%, 60%, 80%, 100% (control run), 120%, and 140%. Land-sea distribution is the same for all experiments and all mountains in the world are uniformly varied. Systematic changes in precipitation and circulation fields as well as sea surface temperature (SST) are obtained with progressive mountain uplift. A north-south jump of the 500 hPa zonal wind axis around the longitude of the Tibetan plateau is found with mountain height higher than 60% between the winter and summer season. On the other hand the jet axis stayed in the northward position all the year round in the experiments with lower mountains. Summertime precipitation is confined in the deep tropics around 10N in the no-mountain (M0) case, but it moves inland on the Asian continent with mountain uplift. Associated with this, an intensification of the Pacific subtropical anticyclone and trade winds is found. The Baiu-like precipitation belt in East Asia clearly appeared at mountains higher than 60%. Summertime southwesterly monsoon flow does not cover the northernmost Arabian Sea region so that upwelling is inactive all the year round when mountain is lower than 40%. The western Pacific warm pool and ENSO also systematically changed. When the mountain height is low, a warm pool is located over the central Pacific due to weak trade winds in the Pacific. The model ENSO is strongest, its frequency is longest and is most periodic in the no mountain run. The model ENSO becomes weaker, shorter and less periodic.
when the mountain height increases. Strengthening the mean state trade winds and narrowing meridional extent of equatorial wind and ocean response by mountain uplift would be responsible for ENSO modulation.

Lastly, we present results of future climate projections at the end of the 21st century by an AOGCM and a very high-resolution atmospheric model (20-km mesh). Analyses on precipitation-based extremes indices show an enormous increase in heavy precipitation in South Asia, Amazon and West Africa, while dry spell index increases in South Africa, South Australia and Amazon, which imply that the risk of water related disasters becons higher in these regions. In the Asian monsoon region, annual maximum 5-day precipitation, which has a strong relation with flood or soil disasters, increases notably in Yangtze River basin and Bangladesh, due to intensified water vapor flux in summer.

Fig. 1. Surface wind distributions in December-February (DJF) and June-August (JJA) seasons for M0 (no mountain case) and M10 (control case).
Simulation of the Asian summer monsoon for the mid-Holocene and the Last Glacial Maximum

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1. Introduction

Climate model simulations and paleoclimatic data suggest that two mechanisms exert the dominant forcing on millennial-scale variations in monsoon strength. First, changes in the orbit of the Earth, predominantly in the precession of the equinoxes, control the amount of insolation reaching the Earth as a function of season, and hence the ability of the Tibetan Plateau to warm in the summer (Prell and Kutzbach 1987). Second, changes in glacial boundary conditions (ice sheet topography and albedo, sea surface temperature (SST), and atmospheric greenhouse-gas concentrations) have been considered to alter the way in which the monsoon can respond to astronomical forcing (Manabe and Broccoli 1985). In this study, we compare the change in the summer Asian monsoon between the mid-Holocene and the LGM using results obtained by a relatively fine resolution numerical model.

2. Model and experiments

The simulations were performed with the Community Climate Model version 3 (CCM3) atmospheric general circulation model at about 75 km with 18 vertical levels. Three experiments are analyzed. The modern climate simulation, referred to as MOD, is forced by climatologically-averaged monthly sea-surface temperatures (SSTs) and sea ice distributions provided by NCAR, a specified CO$_2$ concentration of 355 ppm, and present land mask and topography. The mid-Holocene experiment, called HOL, has identical conditions to the MOD experiment except for the orbital parameters which set for 6k BP. The third experiment features glacial boundary conditions. Over ocean the SST and sea ice are prescribed using climatologically averaged monthly data prepared with the August and February reconstructions by the CLIMAP (1981). The glacial surface topography was modified following the Ice-4G reconstructions and the land mask is modified to account for the lower sea level (~120 m). The atmospheric CO$_2$ concentration is reduced to 200 ppm following ice core data. Vegetation and soil types are unchanged except over glaciated surfaces. Land points arising due to sea level reduction are assigned a medium soil type. Orbital parameters set to 20k BP.
Fig. 1. Geographic distribution of the change in wind vectors at 900 hPa and for a) mid-Holocene and b) LGM, and precipitation for c) mid-Holocene and d) LGM.

3. Results

In the mid-Holocene summer, surface temperature increases in Asian continent by 3-5°C. Associated with the increase in surface temperature, surface pressure becomes deeper inside the continent and this intensifies the landward winds, especially the southwest wind in the Arabian Sea (Fig. 1a). An increase in landward winds is also shown in the northeast Pacific. In the LGM, on the other hand, the surface temperature decreases and consequently sea level pressure increases in the Tibetan Plateau, which leads to a marked decrease in southwest winds and thus the summer monsoon circulation.

The change in spatial wind pattern is closely linked to the distribution of precipitation. In the mid-Holocene summer, precipitation is larger than MOD over most of Asia, especially over Saudi Arabia, India, South Asia, and north East Asia (Fig. 1c). This increase seems to be associated with the increase in landward winds. In the LGM, precipitation decreases in most regions. The precipitation decrease is especially large in western India and western South Asia presumably due to the weakening of the southwest wind in the Indian Ocean.

In conclusion, the Asian summer monsoon becomes stronger in the mid-Holocene and weaker in the LGM. These model results agree with observational proxy evidence and other previous model simulations.
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The 4th International Symposium of IGCP-476

Poster Session
Preliminary report of the loess-paleosol sections in the northern Mongolia

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Recently, loess-paleosol sections in the Northern Mongolian Plateau were reported on which study of their paleoenvironmental records and the last glacial Gobi dynamics was conducted (Feng, 2001; Khosbayar \textit{et al.}, 2003; Feng \textit{et al.}, 2005). The changes in the extent of the Gobi area in Mongolia must have been influenced by the strength of the East Asian monsoon, and affected the eolian flux to the Chinese Loess Plateau, East Asian marginal seas, and the northern Pacific. This in turn, might have impact on climate change and ocean productivity. Therefore, the reconstruction of the paleoclimate changes in the Northern Mongolian Plateau should be important to enhance our understanding of the mechanisms and processes of large-scale climate changes in the past and near future.

To explore the paleoenvironmental records and to infer the northern boundary behaviors of the Gobi, we conducted preliminary study on two loess-paleosol sections in Shaamar region of the Northern Mongolia: (a) the Bayan Tokhoy section (N50°01’49’’; E106°08’49’’; 625 m), and (b) the Buural Ovoo section (N50°02’52’’; E106°08’38’’; 637 m).

The Bayan Tokhoy section is characterized by the alteration of the yellowish white or yellowish brown colored fine to coarse grained sand, yellowish white colored loess, and dark brown or dark grey colored paleosol units. Detailed stratigraphic studies and preliminary age determinations have already conducted on this section (i.e., Feng, 2001; Khosbayar \textit{et al.}, 2003; Feng \textit{et al.}, 2005). Two thin sand layers with burnt charcoal (immediately below the surface soil) were dated at 420±90 and 1469±90 yr BP. Two paleosols bracketing laminated loess were dated at 4780±60 and 13’670±250 yr BP (Feng, 2001; Khosbayar \textit{et al.}, 2003). Although total thickness of the exposed section is only 31m, coring data (by the Mongolian Geological Survey) show that further 20m of loess-paleosol sequence is buried here. The loess, paleosol, and sand units are well defined in this section by the organic matter content and particle size (Feng, 2001; Khosbayar \textit{et al.}, 2003; Feng \textit{et al.}, 2005). That is, all paleosols are characterized by higher organic matter content and finer grain size than the sand units, indicating that less windy conditions and/or higher vegetation density prevailed during paleosol formation (Feng, 2001; Feng \textit{et al.}, 2005).

The Buural Ovoo section is subdivided into two units: the upper one is composed of yellowish white colored sand (Quaternary in age), and the lower one is the alteration of whitish brown colored loess and reddish brown colored paleosol sequences (Late Pliocene in age). The age determinations were based
on mammalian assemblages by Devyatkin (1989). Total thickness of this section is 25 m. This section awaits further investigation.

It is generally accepted that provenance of eolian dust in loess-paleosol sequence records history of dry land development as well as changes in nature, intensity, and route of dust transport wind in East Asia. However, until present, no well-established method exists to extract such information from these eolian sediments. Nagashima et al. (2006 submitted) recently developed the method to characterize eolian dust provenance by utilizing electron spin resonance [ESR] signal intensity of $E^1$ center of quartz, together with crystallinity index of quartz. We plan to apply this method to above two sections in the northern Mongolia. The result will bring us important information on the significance of eolian contribution from northern Mongolia and southeastern part of Siberia to Chinese Loess Plateau, East Asian marginal seas, and northern Pacific.

Reference
Late Pleistocene and Holocene land and sea environmental changes on the west coast of Bohai Bay

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With the developing economy on modern time, the global environment becomes worse and worse. So it is necessary for geologists to study the evolution of the land and sea environmental changes in the recent past and forecast its trend with human influences in the future.

Bohai Bay is one of three bays of Bohai Sea (the other two are Liaodong Bay and Shandong Bay). We learn the local land and sea environmental changes on the West Coast of Bohai Bay by comprehensive studies, including pseudo-3D stratigraphical representation, chronology, grain size analysis, palynology, diatom, mollusk and foraminifera for both shallow and deeper cores.

Fig. 1 is a distribution map of 786 Eijkelkamp cores (the black ones) of which temporary and spatial distribution is for the last ~4000−6000 years and depth of ~4−6 m, respectively, on the Bohai Bay. Each site has been geographically fixed by using portable GPS and topographically leveled by Geodimeter. Such shallow strata have been chronologically studied by radiocarbon, OSL and palaeomagnetism. As a result, it is able to separate the Late Holocene strata into two first-order-hierarchies—

1. The Yellow Unit on the top. It includes salt marsh, Yellow River sediments and the buried soil horizon, etc. And this part corresponds to the top of the MT1 (from the dashed line to the top surface) in Fig. 2.
2. The Gray Unit at bellow. It is the Holocene marine layer. However, it only reflects the shallow part of the MT1 because of shallow penetrating capability of Eijkelkamp augering. So it corresponds to the upper-middle part of MT1 in Fig. 2.

Based on the actual measured sites (the black one in Fig. 1), we insert a number of virtualization spots (the red one in Fig. 1) in the unmeasured area. In this way, each unit and subunit can be pseudo-3D presented, as exemplified by Fig. 1.

Four cheniers were reconstructed for part of Bohai Bay. The radiocarbon data reveal that Chenier IV was 6000-4660 cal BP, Chenier III was 4200-3360 cal BP, Chenier II was 2750-1650 cal BP and Chenier I was 900-150 cal BP. Each Chenier represents a stop of the shoreline migration since the Middle Holocene.
Deeper boreholes were also drilled in native coastal lowland, reclamation area located on the original tidal flat and shallow sea for revealing the local Late Pleistocene and Early Holocene environmental changes. Until now, six boreholes were comprehensively studied (the maximal depth of the core is 95.6 m). Essential results are as follows—

(1) Three marine layers (MT1, MT2 and MT3) existed on the west coast of Bohai Bay since the Late Pleistocene. It suggests that three cycles of tremendous sea level changes occurred since the Late Pleistocene. After the beginning of the Marine Transgression 1 (MT1), i.e. by the beginning of the Holocene, the coast plain has been almost flat (Fig. 2).

(2) The Borehole HZ02 has a big strange thickness of the terrestrial sediments comparing with the other five. Considering the depth of Laotieshan Channel, the outflow channel of the Bohai Bay during the Last Glacial Maximum (LGM), is 70 m below msl, while the bottom of the terrestrial sediments is almost 80 m in HZ02 (Fig. 2), we presume that there maybe a tectonic subsiding near the Haihe River since LGM. Similarly, the MT2 of the Borehole BQ1 is also deeper because it is located inside the Qikou Depression.
Fig. 2. Schematic map showing the lithostratigraphical correlation of the deeper boreholes on the west coast of Bohai Bay. There maybe a tectonic subsidence near the Haihe River shown by HZ02 because its big strange thickness of the terrestrial sediments comparing with the other five boreholes, and the bottom of the terrestrial is even lower than the outflow channel bottom.
Tracking the weight change of foraminifer tests in water column: preliminary results to reconstruct the monsoon impact on oceanic geochemical cycle

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Oba and Pedersen (1999) suggested a potential impact of calcite contained in eolian dust on carbonate budget in the ocean. They claimed that rain drops with higher alkalinity due to dissolved calcite originated from eolian dust could raise the alkalinity of ocean surface water during glacial times which could lowered the atmospheric CO$_2$. This hypothesis does not look popular but could be significant when considering the interrelationship between climatic changes such as monsoon and variability in global geochemical cycles.

Since Lohmann (1995), it is generally believed that the weight of particular planktonic foraminifer test with a similar size is identical when it is formed and it increases with sinking in the water column due to formation of secondary calcite. Finally, the calcite of the foraminifer test affected by dissolution and loose its weight in the deep sea sediments. Broecker et al. (1999) found that the average weight of foraminifer tests with 300-350 µm size correlates well with CO$_3^{2-}$ activity at the water depth of sediment. Therefore, if we could reconstruct the weight of secondary calcite formed in surface to middle depth of the water column and the weight loss in the sediments in the past, and compare with eolian dust flux to the ocean, we would be able to evaluate the impact of dust to the oceanic carbonate budget.

In order to reconstruct the history of weight change of foraminifer tests, we measured weight of individual test and examine the weight distribution. Weight distribution of living G. sacculifer was investigated by Takahashi (1984) which provides us both diameter and weight of individual test. Interrelationship between diameter and weight can be expressed as beautiful power function which is utilized to predict the weight from the diameter. We calculated the normalized weight defined as ratio of the real weight and the predicted weight for each test.

We conducted the analysis on northwestern subtropical Pacific sediments above CCD (KH06-2-KPR-6) and close to CCD (KH06-2-KPR-4). Distribution of normalized weight of living foraminifer tests shows symmetric normal distribution, while those of tests from surface sediments above and closed to CCD are right and left skewed, respectively. Died foraminifers suspended shallower than 500 m water depth and LGM sample shows right skewed distribution. In addition, average weights of these samples are all heavier than predicted weight and LGM sample is heavier than surface sediment samples. These facts suggests that effect of carbonate dissolution is reflected in the skewness of weight distribution and secondary calcite precipitation was more active during LGM than present.
Long-term seasonal sea-ice history of the northern Japan Sea: ice-rafted debris evidence

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Ice-rafted debris, which consists of sand and gravel incorporated into and transported by sea ice and released upon its melting, is sedimentological evidence for the occurrence of sea ice. No continental ice sheet reached the Russian coast of the Japan Sea during the LGM indicates that IRD transported by icebergs is negligible in the Japan Sea. Modern observation of sea-ice expansion in the Sea of Okhotsk suggested that surface-water cooling and wind direction over the sea are important component of its expansion. In the Japan Sea, because both of them are controlled by the degree of the East Asian winter monsoon, a stronger winter monsoon is expected to result in greater sea-ice expansion and a larger amount of sea ice in the northern Japan Sea.

Two sediment cores from the northern Japan Sea were analyzed for reconstruction of the East Asian monsoon fluctuation. Core KR05-09 PC-1 was collected from the Matsumae Plateau. Core bottom age was estimated as 210 ka and averaged sedimentation rate was calculated as 5.9 cm/ky. Another Core KR05-09 PC-2 was recovered from the eastern margin of the Japan Basin floor. It covered 450 ka-long continuous record with averaged sedimentation rate of 4.0 cm/ky. Most of sand and gravel grains obtained were thought to be IRD based on their occurrences. Profiles of IRD counts in each core are concordant with those of magnetic susceptibility. The IRD occurred throughout the cores except of high sea-stands indicating common occurrence of sea ice in the northern Japan Sea except of warmer interglacial periods. IRD occurrence in the southern core PC-1 is smaller in number and shorter in period than that in the northern core PC-2, suggesting smaller influence in the southern site than in the northern site. Pattern of IRD occurrence showed the millennial-scale variability, and did not show the simple relation with the sediment lithology (dark and light layers) reflecting the fluctuation of the East Asian summer monsoon.

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Early Holocene intrusion of warm waters into the Japan Sea through the Tsushima Strait

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The Tsushima Warm Current (TWC) is the only warm water flowed into the Japan Sea through the Tsushima Strait. Previous studies indicated that the start of the intrusion of the TWC was at around 8 ka. However, the detailed story of the warm water inflow through the Tsushima Strait after the Last Glacial Maximum is still unknown because of a few cores suitable for such a study and relatively poor age control in the Holocene sediments of the Japan Sea. Offshore of Tottori, the southwestern Japan Sea, is a favor place to study the characteristics of inflow water properties through the Tsushima Strait, because this is a first place of mud deposition in the intermediate water depths above modern CCD under both the first and second branch of the TWC. Two cores are selected for this study; core GH87-2-308 from the marginal terrace offshore of Tottori under the first branch, and core KR02-06 site D from a small basin on the Oki Ridge under the second branch. Both planktonic foraminifera and radiolarian assemblages in two cores record the changes of surface water properties along the modern first and second branch after LGM as follows. These records indicate that the global sea-level rising and the oceanography of the East China Sea are major control factors for the surface water properties flowed into the Japan Sea.

1) Deglaciation 1 (-13 ka): Cold surface water occupied almost throughout the whole Japan Sea after disappearance of the surface water stratification and its related deep-water bottom anoxia.

2) Deglaciation 2 (13-9.5 ka): The relatively warm East China Sea surface water with low salinity started intrusion through the West Channel of the Tsushima Strait according to the global sea-level rising. Marine pollen record in the central Japan Sea indicated that the gradual warming started at around this period (around 13 ka).

3) Early Holocene 1 (9.5-8.5 ka): Due to the retreat of the East China Sea coastal water from west of Kyushu to west, the Kuroshio-related Tsushima Warm Current was able to intrude into the Japan Sea. The Kuroshio-related water flowed into the Japan Sea through the West Channel of the Tsushima Strait.

4) Early Holocene 2 (8.5-7.3 ka): According to the global sea-level rising, the East Channel opened. Larger influence of the Kuroshio-related water found along modern first branch than along modern second branch.

5) Early-mid Holocene (7.3 ka): Modern surface water conditions off San’in area was established.
Stronger influence both of the East China Sea shelf water and the Kuroshio-related water was caused by the warm water inflow from the South China Sea through the Taiwan Strait and the East China Sea shelf in summer and enhancement of the Kuroshio Current in the central Okinawa Trough.

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Variations of bottom currents in the Ulleung Interplain Gap, East Sea since the Last Glacial Maximum

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The Ulleung Interplain Gap (UIG) is a deep narrow (ca. 2500 m deep and 75 km wide) passage which has served as a conduit for deep-water circulation between the Ulleung and Japan basins of the East Sea (Sea of Japan). The late Quaternary sedimentation in the deep passage was known to be dominated by an interaction between bottom currents along an erosional axial channel system and downslope mass flows from its southeastern margin. In particular, relatively stronger bottom-current activity during the post-glacial period (< ~15 ka) was suggested to result in focused accumulation of resuspended sediments along the axial channel margin. In order to detail the variations of bottom currents in the UIG since the Last Glacial Maximum, we analyzed grain-size distribution of detrital fraction in a piston core sediment (05GCRP-17) from the axial channel margin of the UIG, together with some geochemical (CaCO₃, TOC and opal) parameters. In addition to median diameter (D₅₀) of the whole fraction, the variability in grain-size distribution was also represented by mean diameters of sortable silt (SS: 10-63 µm) which is believed to be more susceptible to selective deposition and winnowing by bottom-current activity. Preliminary age controls for the core sediment were provided by 4 AMS ¹⁴C dates on TOC of bulk sediments and well-known tephra layers of U-Oki and AT.

Lithologic unit during the post-glacial period is characterized by relatively thick (~ 4 m) muddy contourite with a few intercalated turbidite beds. The sedimentation rate during the early stage of the deglaciation (15-16 ka) is especially high (> 2 m/ka), more than 100-fold higher than the LGM. Both D₅₀ and SS mean values are, in general, relatively higher during the early stage of the deglaciation and lower during the Holocene with respect to those during the LGM. In particular, the early stage of the deglaciation is punctuated by high-amplitude centennial cycles superimposed on the overall trend. Because the overall trend in D₅₀ variation is generally consistent with that from a core sediment on top of the South Korea Plateau, where the bottom-current influences might have been negligible, we believe that the overall trend may reflect changes in supply of detrital sediment, rather than variations in bottom-current activity. On the other hand, the superimposed, high-amplitude centennial cycles in both D₅₀ and SS mean variations during the early stage of the deglaciation, together with the extremely high sedimentation rate, suggest possible centennial-scale outbreak or bursting of bottom-water formation in the northern part of the East Sea in centennial scale. The bottom-current activity during that time may
have been much more vigorous than the present, thus, caused significant erosion or non-deposition in the axial channel and rapid accumulation of resuspended sediments along the channel margin.
Update of the Korean IODP activities

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The Integrated Ocean Drilling Program (IODP), built upon the successes of the Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP), is an international marine research program, co-led by Japan and US. The principal themes of IODP are: (1) deep biosphere and the seafloor ocean (2) environmental change, processes and effects, and (3) solid earth cycles and geodynamics. More specific IODP goals and initiatives include: a better understanding of the nature of seismogenic zone; examination of the role of continental breakup in basin formation; gas hydrates as energy resources and carbon reservoirs; and the drilling and monitoring of a complete section of oceanic crust. To achieve these objectives, mainly three drilling vessels will be operated including riser, non-riser, and mission specific platforms. IODP will also provide all member countries in the world access to a vast repository of geological and environmental information recorded in the seafloor sediments and rocks.

Korea joined ODP in 1996 with Canada and Australia as a consortium. With the addition of Chinese Taipei in 1997, the consortium was named the PacRim Consortium. The Korea IODP (K-IODP) was established in 2004 to oversee the ODP- and IODP-related activities during the transitional period from ODP to IODP. Korea joined IODP in June this year as the leading organization member of the newly formed Interim Asian Consortium. The Korea Institute of Geoscience and Mineral Resources (KIGAM) manages K-IODP and is working closely with other geoscience institutions, universities, and private companies in Korea. After officially joining the IODP, Korean IODP community formulated subcommittees and other organizations such as K-IODP Council, Science Committee, Secretariat and the managerial regulations. KIGAM is expected to attract additional members to the Interim Asian Consortium.
Characteristic occurrence of benthic foraminifera during the warm intervals of late Pleistocene and Holocene in the Japan Sea

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The deep-sea bottom environmental of Japan Sea repeated drastic changes during Pleistocene. The dark layers, which occur frequently in the sediment cores, indicate oxygen-deplete condition of the sea-bottom. Among them, the thicker dark layers are considered as the sediment during the lower sea level in the glacial ages. Benthic foraminifera living on or in sea-bottom are important indicators to show the bottom condition of the sea. On Japan Sea, different faunal composition has been recognized between dark and light layers. Particularly in dark layers, dominant of “low-oxygen species” or absent of any species suggests suboxic or anoxic condition. On the other hand, the assemblages in the light-colored layer are more or less similar to those of present Japan Sea with oxygen-rich bottom water. However, their faunal composition is variable, and must be suggest various paleoenvironmental conditions. So, we focus on two warmer intervals, the last inter-glacial age (MIS 5e) and the Holocene Climatic Optimum, and consider the characteristics of those faunas.

Samples for foraminiferal analysis are collected from the cores of IMAGES, MD01-2408 (core length: 3,338 cm) and KR02-06, C-GC8 (core length: 307.5 cm) at the same site of 806m in water depth, off Akita in the eastern part of Japan Sea. The age model for the cores is established by the identification of tephras and dark layers.

All the samples were cut into 2.5 cm thick, and freeze-dried. After dry-weighed, they were soaked in the water, and sieved through a mesh with 0.063 mm opening. The residue of each sample was divided into adequate size in which about 200 benthic specimens are contained, and the all individuals were picked up.

Throughout the cores, such oxic species as Angulogerina ikebei, Eilohedra nipponica, Islandiella norcrossi and Pseudoparrella takayanagii, are dominant in light layers. These species are distributed in the upper to middle slopes in present Japan Sea. On the other hand, in a dark layer, Brizalina pacifica, Globobulimina pacifica, Nonionella globosa, and Stainforthia loeblichi dominate. They are infaunal species living in lower-oxygen condition.

On the foraminifer assemblages from two warmer intervals, the MIS 5e (2,140-1,980 cmbsf in the core MD01-2408) and Holocene Climatic Optimum (above 200 cmbsf in the core C-GC8), we have obtained the following results:

1) The horizons below the warmer interval are recognized by a thicker dark layer and a gypsum-bearing
layer just above it, corresponding to the glacial age, MIS 2 or MIS 6. The foraminiferal assemblages of both cooler horizons are characterized by high frequency of planktonic species and very poor occurrence of benthics.

2) In the warmer intervals, MIS 5e and lower part of MIS 1, benthic assemblages are mainly composed by several oxic species, and are accompanied by Islandiella japonica and Pullenia apertura.

3) Particularly, I. japonica and P. apertura is almost restricted in the warmer interval, though I. Japonica has much wider stratigraphic range.

4) There are some layers where calcareous species are rare or absent in the warmer intervals, suggesting several dissolution events of calcium carbonate.
Late Quaternary paleoproductivity variation of Korea Plateau in the Ulleung Basin, East Sea (Sea of Japan)

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A piston core (05GCRP21), collected from the South Korea Plateau, north of the Ulleung Basin (East Sea), was analyzed to reconstruct the late Quaternary paleoproductivity variation using a variety of geochemical properties such as biogenic opal, total organic carbon (TOC), calcium carbonate (CaCO\textsubscript{3}) contents. Biogenic mass accumulation rate (MAR) was also calculated using individual biogenic component, linear sedimentation rate and dry bulk density. The chronostratigraphy of core 05GCRP21 was established by a comparison of $L^*$ values between core 05GCRP21 and well-dated core MD01-2407 which was collected in the Oki Ridge. Age of core 05GCRP21 was estimated to cover about 180-kyr duration spanning MIS (Marine Isotope Stage) 6. Lithology of the core 05GCRP21 consists mainly of the bioturbated light mud and the dark mud layers, the second of which can be differentiated the dark laminated mud (DLM) layer from the dark bioturbated mud (DBM) layer. According to the geochemical data, opal contents are low in both DLM and DBM except the last DLM in the bottom of core, whereas CaCO\textsubscript{3} and TOC contents are high in dark mud layers. In particular, higher TOC content corresponds to the thin dark layers. The biogenic MAR patterns are also similar to those of the individual biogenic components. Therefore, the paleoproductivity seems to be relatively low during the formation of thick dark mud layers such as MIS 2 and 6, whereas the increased paleoproductivity appears to correspond to the formation of thin dark mud layer during MIS 3, 4, and 5.
Late Holocene environments of Ilsan, Korea, inferred from palynological and diatom records

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Abundant and diverse palynofloras and diatoms have been recovered from Trench BH-4 of Isanpo area, Ilsan located in river-mouth of the Han River. These terrestrial and marine derived assemblages reflect that the paleoenvironmental changes have occurred during the past 2300 years. Erected pollen zone (2 pollen zones and 4 pollen subzones) and diatom zone (2 diatom zones and 6 diatom subzones) indicate that depositional environments have changed from estuary to lowland fluvial plain about 1800 $^{14}$C yr BP. During 2300-1800 $^{14}$C yr BP, Pollen Zone I and Diatom Zone I, elevation 3.31-2.74 m, are characterized by the abundance of hyposaline marine-brackish dinoflagellates and diatoms together with freshwater algae indicating an estuary surrounded by mountain-slope on which mixed coniferous-deciduous broadleaved vegetation forest flourished under wet, warm Temperate climatic conditions. On the other hand, Pollen Zone II and Diatom Zone II, elevation 3.72-3.36 m, are dominated by only freshwater diatoms and common freshwater algae without marine taxa of dinoflagellates and diatoms. These assemblages refer to be lowland fluvial plain that there were river or small ponds since about 1800 $^{14}$C yr BP. Sterilized mountain soil conditions, caused by human activity such as deforestation and cultivation, accelerate an expansion of coniferous vegetation forest replacing the former mixed vegetation forest. The human impact is indicated by the occurrences of cultivated plants, Gramineae, Zea and Fagopyrum combined with synanthropogenic habitats of Ambrosia and Artemisia.
Fig. 1. Location map showing a main trench BH-4 site and a reference trench BH-6 site, Ilsan, mid-western part of Korean Peninsula.

Fig. 2. Composite diagram of biostratigraphy indicating vegetation, depositional environments, climates and human impact.
Holocene sedimentation and sequence stratigraphy of the inner shelf deposits off the Nakdong River, Korea

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New, high-resolution seismic profiles and borehole data allow detailed study of the stratigraphy and evolution of late Quaternary deposits in the inner shelf off the Nakdong River in the Korea Strait. The inner shelf sequence comprises three stratigraphic units (I, II and III, from oldest to youngest), created in response to environmental changes from retrogradational to progradational phases driven by climatic and sea-level changes in the late Quaternary. Unit I above the acoustic basement is characterized by semi-transparent with weakly stratified reflections and consists of estuarine sandy mud or muddy sand including brackish water species of foraminifers with age spanning of approximately 11.5 – 7.6 ka BP. The lightest δ13Corg values (<-23%) and low CaCO3 content (<5%) also indicate that unit I was deposited under an estuarine environment influenced directly by the Nakdong River. Unit II shows semi-transparent seismic facies and consists of a thin veneer of transgressive marine sands with shell debris, originated from reworking of coastal sediments during the postglacial transgression. Unit III is characterized by well-stratified to transparent subbottom reflections and consists of homogenous muds, originated from the Nakdong River, forming a subaqueous delta. AMS 14C age shows that unit II began to be formed at approximately 6 ka BP when sea level was close to the present position. The time also coincides with the initiation of climate warming, resulting in enhancing fluvial sources from the Nakdong River and probably commenced near coeval with the delta initiation, forming unit III.

The characteristic bounding surfaces in the study area are a sequence boundary, a ravinement surface, and a maximum flooding surface. The sequence boundary was formed in response to falling sea level and is a time-transgressive (diachronous) unconformity. The ravinement surface is also a diachronous, resulting from landward migration of shoreface-erosional zone driven by sea-level rise. The maximum flooding surface is an isochronous that occurs when the shoreline has reached its maximum landward excursion at approximately 6 ka BP. Three stratigraphic units above the sequence boundary form a set of transgressive and highstand systems tracts that corresponds to high-frequency (20 ka) sea-level cycle during the late Quaternary. The transgressive systems tract can be divided into two backstepping depositional units separated by the ravinement surface. The lower unit I lying below the ravinement surface consists of estuarine sediments preserved from shoreface erosion and represents a paralic (brackish-estuarine) component of Demarest and Kraft (1987). The upper unit II above the ravinement surface, consisting of transgressive sand produced through shoreface erosion during the
postglacial transgression, corresponds to a marine (nearshore) component. Unit III above the maximum flooding surface represents the highstand systems tract formed during the recent highstand of sea level and is confined to the inner shelf off the Nakdong River, forming a subaqueous delta.
Hanon maar in Jeju Island, Korea: a high-resolution archive of the late Quaternary paleoclimatic and environmental changes

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The Hanon volcano on the southern coast of Jeju Island is a nested maar-scoria cone complex. The crater of the volcano is filled with sediments deposited in a ponded shallow lake or swamp setting. Sedimentological characteristics of a 10 m-long core obtained from the crater-lake deposit were analyzed to reveal the paleo-environmental variations related to the late Quaternary glacial and interglacial paleoclimatic changes. The crater-lake deposit since ca. 32,000 years BP consists mainly of silt- to clay-sized elastic and organic particles, and shows various sedimentary structures including bioturbation, lamination and normal grading. The sedimentary sequence is divided into 4 stratigraphic units based on the sediment texture, magnetic susceptibility, sediment color and sedimentary structures. According to the AMS\textsuperscript{14}C dates, the stratigraphic units correspond to Marine Isotope Stages (MIS) 1 to 3 (<32 ka). Unit 1 above the core depth of 210 cm consists of dark gray to black peaty mud with a very low magnetic susceptibility, and the sediments are highly disturbed by plant roots and other bio-activities. This reflects the rapid climate change from cold and arid to warm and humid climate condition at the Pleistocene-Holocene boundary and an increased input of plant organic materials into the shallow swamp under the warm climatic condition (MIS 1). Units 2 and 3 at the core depth between 210 cm and 780 cm approximately correspond to the last glacial period (MIS 2 and 3) and are characterized by restricted bioturbation and slightly higher silt content and magnetic susceptibility than unit 1, which most probably represents a deposition in a deeper lake setting as well as a dominant influence of strengthened winter monsoon winds coupled with cold and arid climatic conditions of East Asian region during the glacial period. Unit 4 below the core depth of 780 cm is characterized by common intercalation of thick massive to graded sand and gravel layers. This is attributed to a frequent intercalation of mass-flow deposit resulting from the slumps or turbidity currents on the unstable pyroclastic crater rim of the incipient Hanon volcano.
Mid- and late-Holocene peat stratigraphy of the Pyeongtaek blanket peat bog, Korea: preliminary results

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The Korean Peninsula is located in the far northeast of the Eurasian continent, and is surrounded by sea on three sides, with the Yellow Sea to the west, the East China Sea to the south and the East/Japan Sea to the East. Due to these seas’ ameliorating effects, Korea has elements of both continental and maritime-temperate climates, and consequently the paleoenvironmental evolution of the Korean Peninsula has attracted much attention. However, there is a lack of comprehensive survey data involving peatlands.

Herein we report preliminary results of study of two peat sections from the Pyeongtaek blanket peat bog of the Korean Peninsula, HS trench (3.912–5.412 m in altitude) located in Hwangsan area (36°57′25″N, 126°55′52″E) and HY trench (2.075–5.175 m in altitude) located in Hwayang area (36°57′57″N, 126°54′45″E).

Both sections contain several peat layers, which are underlain by dark olive black (2.5Y 3/3) and olive black (7.5Y 2/2) homogeneous mud (less than 10 wt% TOC) with abundant plant fragments (mainly *Trapa*, Water Chestnut). Peat layers can be easily distinguished from the clastic sediments by their high TOC contents (more than 30 wt%). High TOC is suggestive of drier marshy (peat-forming) conditions. The peat layers are composed almost exclusively of partly decomposed plant fragments. Except for vertical color change and presence of horizontal lamination, no lithologic variation is apparent. From HS unit-3 (estimated age: 6130 14C yrBP) and HY unit-3 (estimated age: 6200 14C yrBP), TOC values increase upward with small fluctuations, and reach around 45 wt%. The TOC/TN ratios range from 10 to 20 in general.

In HS section, HS units-4 (estimated age: 6040 14C yrBP) and 6 (estimated age: 4410 14C yrBP) have TOC contents that are relatively low, with values between 10 and 25 wt%. Two layers with lower TOC values can be also found in HY section. HY units-4 (estimated age: 5750 14C yrBP) and 6 (estimated age: 5150 14C yrBP) contain 20–25 wt% TOC.

Magnetic susceptibility (MS) is mainly controlled by the magnetic minerals, which are included in detrital sediments. Thus, high MS can serve as complementary evidence of enhanced sediment transportation. Peaks in MS occur at HS units-4, 6 and HY units-4, 6, representing an increase in mineral
matter. TOC values are in negative relation to MS.

The first peat accumulation in both HS and HY sections starts coincidentally around 6200 $^{14}$C yrBP. As the major determinant for the formation of peat is the climatic combination of precipitation and temperature, the climatic changes which led to decreased precipitation would be the one of the possible causes for the onset of peat formation. However, the timings of low TOC contents layers are differ from each section. This disagreement indicates that the controlling factor of the enhanced sediment transportation is not region-wide (e.g. fluctuations in precipitation or input of eolian dust). These variations are probably related to the activities of ephemeral river system, which may be responsible for the increased input of mineral matters.

Simplified stratigraphic section of the HS trench

Simplified stratigraphic section of the HY trench
Atmospheric CO\textsubscript{2} consumption in the Three Rivers region in eastern Tibet

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Three large rivers—the Chang Jiang (Yangtze), Mekong (Lancang Jiang) and Salween (Nu Jiang)—originate in eastern Tibet and flow across suture zones and faults generated by the collision of the India and the Eurasia. The three rivers run in close parallel over 300 km, near the eastern Himalayan syntaxis. The 74 water samples collected in summer, 1999 to 2004, display widely varying major element compositions reflecting the complex geologic makeup of the drainage basin. The total dissolved solids (TDS) range from 30 to 3000 mg/l. While the main channel samples are influenced by carbonate weathering, some headwater tributary samples of the Chang Jiang in the Tibetan Plateau interior are dominated by evaporite dissolution, as evidenced by high TDS (928 and 3036 mg/l) and Na-Cl dominant major element composition. Local tributary samples of the downstream Mekong and the Salween near the Lincang Batholith (LB) show distinctive silicate weathering signatures. The $^{87}$Sr/$^{86}$Sr ratio in the Three Rivers region (TRR) ranges from 0.7088 to 0.7296. Sr isotope is greater than 0.725 are found near the LB. Five reservoirs—rain (atmosphere), evaporite, carbonate, sulfate, and silicate—are considered in a forward model to calculate the contribution to estimate the consumption rate of the atmospheric CO\textsubscript{2}. The last mainstream samples of the TRR indicate that carbonate weathering accounts for about 50% of the total cation charge (TZ\textsuperscript{+}) in the Mekong and the Salween. The Chang Jiang, however, shows 45% of evaporite weathering in terms of TZ\textsuperscript{+} because of the extreme headwater tributary samples. Net CO\textsubscript{2} consumption rate of the TRR ranges from 108 to 128 \times 10\textsuperscript{3} mol/km\textsuperscript{2}/year. It is similar compared to other large rivers draining the Himalayas-Tibetan Plateau. Statistical analyses using the stepwise linear regression indicate that runoff is a primary factor controlling the carbonate weathering rate at a 95% confidence level ($r^2 = 0.83$, $p = 0.00$). Relief and slope have no significant correlation with chemical weathering rates.
Chemical weathering in the Hong (Red) River Basin: rates of silicate weathering and their controlling factors

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The Hong (Red) River drains the prominent Red River Fault Zone that has experienced various tectonic activities—intrusion of magma, exhumation of basement rocks, and influx of thermal waters—associated with the collision of India and Eurasia in the Cenozoic. We report dissolved major element and Sr isotopic compositions of 43 samples from its three tributary systems (Da, Thao/Hong main channel, and Lo) encompassing summer and winter seasons. The three sub-basins display distinctive characteristics: carbonate-silicate two end-member mixing in the Lo, and an additional end member with high concentrations of Na, Cl, K, and SO₄ in the Da and Thao. Seasonality is manifested in higher calcite saturation index, Mg/Na, and Si/Na and lower Ca/Mg in summer at 5% significance level. We quantified chemical weathering rates using forward and inverse models and examined the robustness of the results. Carbonate dissolution accounts for a significant fraction of total dissolved cations (60–95%), and weathering of silicates makes a minor contribution (1–35%). Our best estimate of spatially averaged net CO₂ consumption rates by silicate weathering in the Hong basin is 183 × 10³ mol/km²/yr in summer and 46 × 10³ mol/km²/yr in winter. Use of different models and end member constraints can yield rates 142–244 × 10³ mol/km²/yr in summer and 36–61 × 10³ mol/km²/yr in winter. The contribution to total dissolved cations from silicate weathering (α_{sil,Cation}) in winter is increased by ~3% (~20% of summer), but the CO₂ consumption rate is ~4 times higher in summer because of higher runoff. We tested correlations between the CO₂ consumption rates by silicate weathering and various climatic (air temperature, precipitation, and runoff) and geologic (relief, slope, and lithology) factors calculated using GIS. An apparent correlation with runoff attests to seasonal effect and is not a suitable analogy for climate change over longer timescales. Correlation with geologic factors is poor and statistically insignificant at the resolution tested.
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