

## Reconstruction of atmospheric CO<sub>2</sub> and O<sub>2</sub> concentrations during the last 100 million years based on a model

Toshiyuki Morimi<sup>1\*</sup>, Eiichi Tajika<sup>1</sup>, Kazumi Ozaki<sup>2</sup>

<sup>1</sup>Department of Complexity Science and Engineering, University of Tokyo., <sup>2</sup>Department of Earth & Planetary Science, University of Tokyo.

Reconstruction of atmospheric carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>) concentrations in the past is a key to understand the evolution of environments and life. Accumulating geological and geochemical data with accurate chronology enable us to consider the dynamics of atmospheric composition and its controlling mechanisms. The paleo-atmospheric CO<sub>2</sub> and O<sub>2</sub> concentrations have been discussed from proxies and theoretical modeling with geological and geochemical data.

One of these models, GEOCARBSULF (Berner, 2006, GCA) is a standard which studies changes of atmospheric CO<sub>2</sub> and O<sub>2</sub> over Phanerozoic time (for 542 million years). In the model, various geochemical processes, such as chemical weathering of minerals and CO<sub>2</sub> degassing via volcanisms and metamorphism are considered, and geological and geochemical data are given for every 10 million years as boundary conditions.

The reconstructed evolution of climate and atmospheric composition are broadly consistent with geological and geochemical data. However the reconstructed atmospheric CO<sub>2</sub> in the last 150 million years are evidently different from compiled CO<sub>2</sub> proxy data such as stomata, phytoplankton, paleosols and liverworts. For instance, GEOCARBSULF overestimates the atmospheric CO<sub>2</sub> before 100 Ma. The difference between the results from the theoretical model and from the CO<sub>2</sub> proxies may be partly because of low time resolution data of carbon and sulfur isotopes of seawater, and of other boundary conditions, and also because of effects of the processes GEOCARBSULF does not considered.

In this study, we will focus on the reconstruction of atmospheric CO<sub>2</sub> and O<sub>2</sub> changes during the Cretaceous and Cenozoic time (over the last 145 million years), with a modified GEOCARBSULF model and high time resolution data of carbon and sulfur isotopes, including effects of processes, such as eruptions of large igneous provinces, emergence of foraminifera during the Jurassic, and so on.

Keywords: carbon dioxide, oxygen, reconstruction, Mesozoic, Cenozoic, GEOCARBSULF

## Vector diagram analysis of ocean carbon pumps during the Last Glacial Maximum

Akira Oka<sup>1\*</sup>

<sup>1</sup>Atmosphere and Ocean Research Institute, University of Tokyo

Using ocean carbon cycle model simulations of present-day and glacial climates, this study discusses the glacial responses of the ocean carbon pumps: organic matter, calcium carbonate, gas exchange, and freshwater pumps. The vector diagram presented here quantifies their individual impact on the glacial atmospheric pCO<sub>2</sub> reduction; the strengthening of the organic matter pump contributes to 40-ppm reduction of atmospheric pCO<sub>2</sub>, most of which is cancelled by the weakening of the gas exchange pump. The response of the gas exchange pump is involved in various processes. Here, they are systematically revealed through analysis of additional sensitivity simulations. The analysis suggests that changes in the ocean deep circulation significantly affect the response of the gas exchange pump; the above-mentioned strong cancelation between the organic matter pump and the gas exchange pump is related to the glacial weakening of the Atlantic deep circulation. As in previous studies, the model used here fails to reproduce the observed magnitude of the glacial pCO<sub>2</sub> reduction. Reduced ventilation in the glacial Southern Ocean is a possible mechanism for explaining this difference since this has the potential to significantly modify the glacial response of the gas exchange pump but may not accurately be reproduced in the model. Although the gas exchange pump has often been implicitly incorporated into other processes, this study suggests that its response is a key to understanding glacial changes in atmospheric pCO<sub>2</sub>. It is also demonstrated that the vector diagram is a useful tool for its investigation.

## $^{230}\text{Th}$ -normalized flux of biogenic components recorded in the Chilean margin since the last glaciation.

Miho Fukuda<sup>1\*</sup>, Naomi Harada<sup>2</sup>, Miyako Sato<sup>2</sup>, Carina B. Lange<sup>3</sup>, Naokazu Ahagon<sup>2</sup>, Silvio Pantoja<sup>3</sup>, Hajime Kawakami<sup>2</sup>, Isao Motoyama<sup>4</sup>

<sup>1</sup>Univ. Tsukuba, <sup>2</sup>JAMSTEC, <sup>3</sup>Univ. of Concepcion, <sup>4</sup>Yamagata Univ.

During the last glacial maximum (LGM), the atmospheric partial pressure of  $\text{CO}_2$  ( $p\text{CO}_{2atm}$ ) was quite low, 180-190 ppm and rapidly increased to 280 ppm during the last deglaciation (Monninn et al., 2001, Science, 291, 112-114). The combination of the biogeochemical (e.g. export flux, nutrient utilization) and physical processes (e.g. upwelling, stratification) has been considered to control  $p\text{CO}_{2atm}$ . Considering the response of  $p\text{CO}_{2atm}$  on global climate changes, the polar ocean such as Southern Ocean is one of the most important area linking between atmosphere and ocean, because the deepest water mass can directly connects to the atmosphere and the largest carbon reservoir in the world oceans. During glacial periods, strengthened productivity and an efficient biological pump in the North Pacific, equatorial Pacific, and Southern Oceans may have contributed to low  $p\text{CO}_{2atm}$ . However, there is still some controversy as to whether marine productivity was high everywhere during glacial periods. Resolving this controversy requires more data from many regions regarding temporal changes in past export fluxes of biogenic materials, especially in the eastern South Pacific Ocean including the Chilean marginal region, where active biological production is observed at present. The aim of this study was to identify changes in the  $^{230}\text{Th}$ -normalized export flux of biogenic components commonly used as proxies for paleoproductivity—namely total organic carbon (TOC), total nitrogen (TN) and biogenic opal ( $\text{Si}_{opal}$ ) from two sediment cores collected at 36° S, off central-south Chilean covering the past 22 kyr (PC-1) and at 52° S near the mouth of Strait of Magellan, Pacific side over the past 13 kyr (PC-3).  $^{230}\text{Th}$ -normalized fluxes of biogenic components of sediments at 36° S and 52° S off the Chilean coast imply that the biological pump was effective during 14-8 kyr BP off central Chile, and after 5 kyr BP off central and southernmost Chile; and less effective during 22-14 kyr BP off central Chile and during 13-6 kyr BP off southernmost Patagonia. That is to say, off central Chile, the weakness of the biological pump during the LGM contributed to the global rise of  $p\text{CO}_{2atm}$  at that time. During 14-8 kyr BP, the increasing effectiveness of the biological pump at the PC-1 site off central Chile contributed to the global rise of  $p\text{CO}_{2atm}$ . At the PC-3 site, the weakening of biological pump contributed to the rise of  $p\text{CO}_{2atm}$  during 13-6 kyr BP. After 6 kyr BP, the active biological pump did not contribute to the global rise of  $p\text{CO}_{2atm}$ .

In this presentation, we will also discuss about comparing to  $^{230}\text{Th}$ -normalized fluxes of biogenic components at the 55° S collected from the Drake Passage (PC-9).

Keywords: Off Chile,  $^{230}\text{Th}$ -Thorium, Biogenic components, Biological pump

## Glacial to deglacial productivity and ventilation changes in the southern Okhotsk Sea

Yusuke Okazaki<sup>1\*</sup>, Katsunori Kimoto<sup>2</sup>, Hirofumi Asahi<sup>3</sup>, Miyako Sato<sup>2</sup>, Yuriko Nakamura<sup>2</sup>, Naomi Harada<sup>2</sup>

<sup>1</sup>Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, <sup>2</sup>Japan Agency for Marine-Earth Science and Technology, <sup>3</sup>Pusan National University

The Okhotsk Sea plays an important role in the ventilation of the North Pacific as a source region of the North Pacific Intermediate Water. Glacial to Holocene Delta 14C records of benthic foraminiferal shells suggested enhanced ventilation in the Okhotsk Sea during the early deglacial period corresponding to the Heinrich event 1 (H1) and the Holocene. CaCO<sub>3</sub> preservation events and productivity change appears to be more associated with the ventilation history of the Okhotsk Sea than surface production by coccolithophore and foraminifera. CaCO<sub>3</sub> preservation started to become better during H1 and pronounced %CaCO<sub>3</sub> peaks were coincident with the Bolling-Allerod and Preboreal. Diatom and coccolithophore productivity had kept low throughout the glacial to deglacial periods, which was different from that of the open subarctic Pacific where high productivity observed during BA. After the deglaciation, biogenic opal and decrease in Delta 15N gradually increased throughout the Holocene. The Holocene Okhotsk Sea is characterized by enhanced productivity with relaxation of nitrate limitation.

Keywords: Okhotsk Sea, Last glaciation, Last deglaciation, Productivity, Ventilation

## Paleoenvironmental changes since the Last Glacial Maximum based on C, N and S element concentrations around Okinawa

Atsuko Amano<sup>1\*</sup>, Takuya Itaki<sup>1</sup>

<sup>1</sup>GSI, AIST

In order to reconstructing paleoenvironmental changes since the Last Glacial Maximum (LGM), we collected two gravity cores located in the eastern (GH08-2004) and western (GH10-2011) area of Okinawa Island and analyzed total organic carbon (TOC), total nitrogen (TN), total inorganic carbon (TIC) and total sulfur (TS) concentrations and radiolarian assemblages.

Concentrations of TOC and TN of GH08-2004 were relatively high at 25-16 cal kyr and decreased after 16 cal kyr. Values of TOC/TN ration (C/N ratio) at 25-12 cal kyr were 7-8 and higher than those at 12-0 cal kyr. The relationship between TOC and C/N ratio show a good positive correlation and this result suggests that the amount of terrestrial organic matter affects variations of deposited amount of organic matter. Although TOC and TN concentrations of GH10-2011 increased at 14-7 cal kyr, C/N ratios show little change. Ratios of TOC/TS in two cores were 4~8 and these results indicate that redox condition in the seafloor environment was stable since the LGM. Variations of these properties indicate that the supplied amount from the land increased during low sea level in the last glacial stage and this influence decreased accompanying with rising of sea level. While, influences of supply from the land contribute little to the deposition environment at GH10-2011 because there were at the small basin detached islands.

Total inorganic carbon concentrations of two cores show commonality variations which these values are relative low (<4%) until 7 cal kyr and rapidly increases after 7 cal kyr. TIC concentrations until 7 cal kyr of GH10-2011 were stable, however, those of GH08-2004 decreased in 2% at 14~7 cal kyr. And radiolarian assemblage results show an increase of *Tholospyris spp.* inhabited in the equatorial area. These results suggest that the productivity of such as coccolith and foraminifer was relatively low in the last glacial stage and increased since 7 cal kyr. And a decreasing in TIC of GH08-2004 implies that the productivity at eastern part of Okinawa Island decreased by the influence of oligotrophic sea water around the equatorial area.

Keywords: sediment, CNS elements, radiolaria, sedimentary environment, sea level change, productivity

## Changes in current system in the Arctic Ocean since the last glacial period: A mineralogical approach

Masanobu Yamamoto<sup>1\*</sup>, Daisuke Kobayashi<sup>1</sup>, Yu-Hyeon Park<sup>1</sup>, Seung Il Nam<sup>2</sup>, Naomi Harada<sup>3</sup>, Kana Nagashima<sup>3</sup>, Kazuhisa Chikita<sup>4</sup>

<sup>1</sup>Faculty of Environmental Earth Science, Hokkaido University, <sup>2</sup>Korean Polar Research Institute, <sup>3</sup>JAMSTEC, <sup>4</sup>Faculty of Science, Hokkaido University

Changes in current system regulate the fate of sea ice in the Arctic Ocean and is involved in the processes of global climate changes via ice albedo feedback and the delivery of freshwater to the North Atlantic Ocean. Past changes in the current system and their relationship to global climate changes are, however, not clear. The Chukchi Sea is located at the region where the East Siberian Current (ESC) meets the Beaufort Gyre circulation (BG) and becomes the Transpolar Drift (TPD). Bering Strait Inflow (BSI) transports detrital matter from the Bering Sea to the Chukchi Sea. We can thus reconstruct changes in ESC, TPD, BG, BSI by analyzing sources of detrital matter in Chukchi Sea sediments.

In this study, we analyzed mineral composition in the cores retrieved from the Chukchi Sea and the Chukchi Borderland and the surface sediments from the Bering Sea, the Chukchi Sea, and the Chukchi Borderland (the Northwind Ridge to the Mendeleev Ridge) by XRD and assigned the sources of detrital matters.

Analysis for surface sediments indicated that chlorite/illite ratio is higher in Bering Sea and decreases northwards in the Chukchi Sea, reflecting the influence of the BSI. In the Chukchi Borderland, feldspar/quartz ratio is higher in Siberian margin and lower in Alaskan margin, reflecting the ice drift by the ESC and the BG. Dolomite intensity is higher in Alaskan margin, reflecting the ice drift of the BG.

Analysis for six cores from the northern Chukchi Sea and the Chukchi Borderland indicated that feldspar/quartz ratio was lower and dolomite intensity was higher in the last glacial than in the Holocene. This indicates that the BG was more intensified in the LGM than in the Holocene. Feldspar/quartz ratio gradually increased in the early Holocene and reached to the same level of the late Holocene at 6 ka. Chlorite/illite ratio gradually increased in the early and middle Holocene and reached the same level of the late Holocene at 3 ka.

Keywords: The Arctic Ocean, The Chukchi Sea, Last glacial, The Holocene, Current, Mineral

## Reexamination for the Greenland Ice sheet reconstruction at LGM from the raised beach deposits

Hideki Miura<sup>1\*</sup>, MAEMOKU, Hideaki<sup>2</sup>, OKUNO, Jun'ichi<sup>1</sup>

<sup>1</sup>National Institute of Polar Research, <sup>2</sup>Hiroshima University

The past melting history of the Greenland ice sheet is the great key for elucidating the future sea-level rising. The GIA (Glacial isostatic adjustment) model using the spatial and temporal variations of relative sea-level changes is one of useful techniques for the reconstruction of ice melting history. Although many radiocarbon dating ages for the reconstruction of the sea-level history have been obtained from the coastal area of Greenland (ex. Kelly, 1973; Ten Brink, 1974, 1975; Weidick, 1968, 1972 in West Greenland), the detailed geomorphological and Quaternary stratigraphical investigations have not been enough. For example, though Reeh (1989) and Henriksen (2008) compiled the map showing the amount of uplift during the Holocene along the coastal area of Greenland, some isolated high coastal existences of the place of the amount of upheaval suggest that the field confirmation of Holocene marine limits is questionable. Actually, Fleming and Lambeck (2004) have tried to make the GIA models of Greenland since the Last Glacial Maximum (LGM) to reproduce the sea level history with extraordinary upheaval point and obtained the result that changes in ice thickness since the LGM were > 500 m along the present-day outer coast and > 1500 m along some parts of the present-day ice margin. In this presentation, we introduce the report of the reappraisal for the melting history of the Greenland Ice sheet from detailed geological analysis on the raised beach deposits and GIA modelling.

Keywords: Greenland Ice Sheet, Last Glacial Maximum, raised beach deposits, glacial isostatic adjustment

## Examination for algal biomarker thermometry in sediment cores from the northwestern Pacific off Japan

Kei Miki<sup>1\*</sup>, Ken Sawada<sup>1</sup>, Madoka Kobayashi<sup>1</sup>

<sup>1</sup>Faculty of Science, Hokkaido University

Biomarker thermometers such as alkenone unsaturation index (UK37 and UK'37) have been often used for reconstructing paleo-sea surface temperatures from 1980s. The alkenone are well known to be derived from Haptophycean algae, which are ubiquitous species in shallow to open ocean areas at low to high latitude, and therefore, their thermometers are powerful proxies in the almost over the world oceans. However, it has been pointed out that there were limitations for alkenone proxies; physiological effect, deflection of temperature records during the season of high production, variability of source species, and so on. More recently, long chain alkyl diols such as C28 and C30 1,13-diols, 1,14-diols, 1,15-diols were proposed to be useful as proxy for paleotemperature of sea surface layer (Rampen et al., 2009; 2012). These compounds are likely to be derived from diatom, especially Proboscia, and eustigmatophyte. In the present study, we examine the applicability of such diatom biomarker thermometer from sediment cores from the northwestern Pacific off Japan.

Sediment cores were collected by multiple corer from the Nishishichitou Ridge (LM3 and LM5P, off central Japan; Sawada and Handa, 1998) and off the coast of Sanriku, northeastern Japan (LM8). Freeze dried sediment samples were ultrasonically extracted, and the extracts were fractionated by silica gel chromatography. Polar fraction was silylated by BSTFA before analyses using GC/MS (Sawada and Shiraiwa, 2004). Long chain diol index (LDI) was calculated according to the equation (Rampen et al., 2012) as follow:  $LDI = [C30\ 1,15\text{-diol}] / ([C28\ 1,13\text{-diol}] + [C30\ 1,13\text{-diol}] + [C30\ 1,15\text{-diol}])$ .

We identify saturated C28 and C30 1,13-diols, C28 and C30 1,14-diols, and C30 and C32 1,15-diols in all sediment samples. The LDI values are linearly related to annual mean sea surface temperatures (SSTs) among sites of LM3, LM5P and LM8. In addition, C27 and C29 12-hydroxy methyl alkenoates (12-OH m.a.) are detected in all samples, and we establish new index, 12-hydroxy Methyl Alkenoate index (MA12), which is calculated by the equation as follow,  $MA12 = [C29\ 12\text{-OH m.a.}] / ([C27\ 12\text{-OH m.a.}] + [C29\ 12\text{-OH m.a.]}$ ). Down core profiles of the diols and methyl alkenoates in surface layers of 30 cm depth show that the concentrations are exponentially decrease, but the LDI and MA12 values are nearly constant. From these results, it can be seen that the diol and alkenoate ratios are hardly affected by early diagenesis in sediment-water interface.

Keywords: surface sediment, diol thermometer, alkenone thermometer, multiple core, the northwestern Pacific off Japan



## High-resolution records of Uk'37- and TEX86L-based temperature off Tomakomai, Hokkaido for the last 3000 years

Michinobu Kuwae<sup>1\*</sup>, Masanobu Yamamoto<sup>2</sup>, Takuya Sagawa<sup>1</sup>

<sup>1</sup>Senior Research Fellow Center, Ehime University, <sup>2</sup>Faculty of Environmental Earth Science, Hokkaido University

For understanding the regional climate forcings, internal variability, system feedbacks, and the responses of surface climate and for comparing with regional-scale climate model simulations, importance of high resolution paleoclimate records for the past 2 millennia has been recognized in recent years. Because of lack of age controls and time resolution, many parts of the globe lack adequate paleoceanographic records in comparison with model simulations. In this study, we obtained high resolution records of UK'37- and TEX86L-derived temperature off Tomakomai, Hokkaido for the last 3000 years. From observations of sediment trap experiments, alkenone fluxes were higher from spring to fall and GDGT in early summer and winter in the western North Pacific. A mean value of TEX86L -derived temperature were 5.5 degree C lower than that derived from UK'37 and centennial-scale variations differed between the records. On the other hand, TEX86L-based temperature showed similar patterns of centennial variability in planktonic foraminiferal oxygen stable isotope ratio that reflected winter temperature in Off Shimokita Peninsula. This indicates our TEX86L-derived temperature may reflect climate signals primarily in winter in the western North Pacific. UK'37-derived temperature reconstructions demonstrated warm stage between 1000 BC and 300 BC, cooling trend between 300 BC and 100 AD, fluctuating between 100 AD and 600 AD, warm stage between 600 AD and 1300 AD, and cold stage between 1300 and 1700 AD. These multicentennial variations showed similar patterns to those in UK'37-derived temperature from temperate regions around Japan including off Sanriku (Minoshima et al., 2007), off Joban (Isono et al., 2009), and Beppu Bay (Yamamoto unpublished), indicating that the observed multicentennial variations are associated with climate dynamics controlling summer SST in the temperate and subarctic regions of the western North Pacific.

Keywords: Uk'37, TEX86, paleotemperature, late Holocene, western North Pacific

## Origin of coastal sand and dredged marine sediment around Iki Island, Nagasaki Prefecture

Mariko Sanada<sup>1\*</sup>, Yoshio Inouchi<sup>2</sup>, Naoya Iwamoto<sup>3</sup>, Yuki Nakamura<sup>4</sup>

<sup>1</sup>School of Human sciences, Waseda university, <sup>2</sup>Faculty of Human Sciences, Waseda University, <sup>3</sup>Ehime Prefectural Science Museum, <sup>4</sup>Atmosphere and Ocean Research Institute, The University of Tokyo

Iki island which lies in the western part of Genkai Nada Sea, between Kyushu Island and Tsushima Island, Nagasaki Prefecture, has an area of 134 square kilometers.

Active sand dredgings are carried out around Iki island. These activities have caused coarsening of marine sediment and topographic changes and influence on fisheries by distribution of suspended particles and coastal erosion are attracted public concern.

In this presentation, we will deal with coastal erosion among above mentioned issues.

Grain size analysis and coarse fraction analysis were carried out on dredged sediment and beach sandy sediment.

Dredged sand and beach sand are clearly distinguished based on grain size and sorting index. In addition, dredged sand can be easily distinguished from beach sand by coarse fraction composition for including iron stained quartz and many rock fragments and silicate minerals. On the other hand, beach sand can be distinguished by containing many biogenic fragments and less silicate minerals and rock fragments.

Iron stained quartz is regarded as index for relict sediment which derived from sediment of lower sea level during glacial age. On the other hand, origin of beach sand is supposed to come from beach erosion of rocks, flood sediment or reworked shallow sea sediment containing biogenic fragments. Based on these results, dredged sand differs in origin from beach sand and has no relation to coastal erosion.

Keywords: sediment, iron stained quartz, coastal sand, Iki island, grain size analysis, sand grain assemblage

## Relationship between carbonate ion concentration in the deep-sea and density of foraminifera shell based on X-ray CT

Shinya Iwasaki<sup>1\*</sup>, Katsunori Kimoto<sup>2</sup>, Osamu Sasaki<sup>3</sup>, Harumasa Kano<sup>3</sup>, Yusuke Okazaki<sup>1</sup>

<sup>1</sup>Department of Earth and Planetary science, Kyushu university, <sup>2</sup>Japan Agency for Marine-Earth Science and Technology, <sup>3</sup>The Tohoku University Museum

The Antarctic ice core records revealed glacial CO<sub>2</sub> concentrations in the atmosphere was ~80 ppm lower than that of during the interglacial periods (Barnola et al., 1987). The mechanism of low atmospheric pCO<sub>2</sub> during the glacial period is one of the most important problems in the field of paleo-climate. Carbon pool in the deep sea is 60 times as large as the atmosphere. Thus, most of paleoclimate scientists consider that the deep-sea must have played a key role in carbon cycles during glacial-interglacial periods. However, there is no broadly accepted evidence. In order to explain the low atmospheric pCO<sub>2</sub> during the glacial period, carbonate ion concentration [CO<sub>3</sub><sup>2-</sup>] in the deep sea water mass must be ~40 micro mol kg<sup>-1</sup> lower than that of modern one (Broecker and Peng, 1993).

Oceanic CaCO<sub>3</sub> cycle (CaCO<sub>3</sub> preservation and dissolution) with glacial-interglacial cycle is a key to solve this problem. Carbonate saturation state (Omega) of a particular water sample is

$$\Omega = ([Ca^{2+}][CO_3^{2-}])_{SAMPLE}/K_{sp}$$

[Ca<sup>2+</sup>] of open ocean is constant at glacial-interglacial timescales. Therefore, [CO<sub>3</sub><sup>2-</sup>] is the important factor in determining saturation state. In previous studies, several proxies that aim to reconstruct the past [CO<sub>3</sub><sup>2-</sup>] in the deep-sea were suggested. However, there is no established quantitative proxy for [CO<sub>3</sub><sup>2-</sup>]. Objective of our study is to develop a novel quantitative proxy for past [CO<sub>3</sub><sup>2-</sup>] based on density of foraminiferal shell (micro-plankton with CaCO<sub>3</sub> shell). We used Micro-focus X-ray CT Scanner (MXCT; ScanXmate L080, Tohoku University Museum) to measure density of foraminifera shell accurately. MXCT is a non-destructive research technique which allows investigating internal structure of foraminifera shell in 3D. This enables to evaluate progression of dissolution in the foraminifera shell. Today, this proxy has not been accepted as paleoceanographic method. Thus, in this study, We will develop the MXCT method into a novel quantitative proxy for past [CO<sub>3</sub><sup>2-</sup>] in the deep-sea.

Planktic foraminifera species (*Globigerina bulloides*) from eight sea-surface sediment samples ranging from 1362 to 3135 m water depths were obtained from the western North Pacific. These foraminifera samples were used for shell density measurements by MXCT. In addition, measurement on shell weight by ultra-micro balance (UMT2, Mettler Toledo) and fragmentation ratio of foraminifer shells were performed. In order to understand a relationship between density of foraminifera shell and [CO<sub>3</sub><sup>2-</sup>] in the deep-sea, obtained data were compared with the [CO<sub>3</sub><sup>2-</sup>] in the deep-sea calculated based on chemical analysis in sea-water samples by JAMSTEC Data Search Portal. Our preliminary MXCT results employing planktic foraminifera shells in sediment trap samples (i.e., non-dissolved shells) at Station K2 suggested that density of foraminifera was size dependent. In order to estimate the size effect on shell density, we selected 10 planktic foraminifera shells with similar shell size from each surface sediment sample and measured single shell weight of each 10 shells. As a result, qualitative relationship between the shell weight and [CO<sub>3</sub><sup>2-</sup>] in the deep-sea was shown, supporting a theory that carbonate dissolution is controlled by [CO<sub>3</sub><sup>2-</sup>] in the deep-sea. We will discuss on detailed relationship between foraminifera shell density and [CO<sub>3</sub><sup>2-</sup>] in the deep-sea.

Barnola, J.M. et al., 1987, Nature 329, 408-414.

Broecker and Peng, 1993, Greenhouse Puzzles. Eldigio Press

## Relationships between modern speleothem formation and surface weather in Southeast Asian equatorial cave

Wataru Hasegawa<sup>1\*</sup>, Yumiko Watanabe<sup>1</sup>, Takahiro Tagami<sup>1</sup>

<sup>1</sup>Earth and Planetary Sciences, Graduate school of Science, Kyoto Univ.

To predict future climate change and prepare it is large scientific and social problem. For precise climate prediction, it is necessary to reconstruct high time and space resolution paleo-climate (especially past 2000 years) by paleo-climate proxies and reflect the result to climate model. Equatorial Southeast Asia, where include Indonesia, is well affected by El Nino Southern Oscillation (ENSO). ENSO do not only directly affect to precipitation in tropical Southeast Asia, but also significantly affect to middle and high latitude climate through heat transport (Hastenrath, 1991). However, continuous paleo-climate data in that area is few (IPCC, 2007), thus paleo-climate reconstruction is particular necessary.

Speleothems are useful as a paleo-climate proxy because they are grown continuously in cave (Fairchild et al., 2006). It is known that  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values of speleothem and instrumental data of precipitation are inversely correlated (e.g. Zhang et al., 2008). However, relationship between modern speleothem formation and surface weather (e. g. recording mechanism of precipitation in stalagmites, how large or in which season precipitation is recorded in) is not revealed clearly.

Thus, in this study, cave monitoring, which included surface meteorological observation (air temperature, precipitation and  $\delta^{18}\text{O}$ ), cave meteorological observation (air temperature, airflow direction and speed and  $\text{CO}_2$  concentration), chemical analysis of dripwaters (pH, calcium ion concentration, bicarbonate ion concentration, partial pressure of  $\text{CO}_2$ , calcite saturation index,  $\delta^{13}\text{C}$ , and  $\delta^{18}\text{O}$ ) and speleothem growth experiment (growth rate,  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ), is started from October 2011 in Petruk Cave, Central Java, Indonesia.

Stable isotope value of speleothems is affected by temperature, humidity, drip rate (Day et al., 2011), cave air  $\text{CO}_2$  concentration and calcite saturation index of dripwater (Fairchild et al., 2006). As a result of past monitoring, it is revealed that cave air  $\text{CO}_2$  concentration might be predominant factor of fluctuation of speleothems stable isotope value, because temperature, humidity and drip rate in Petruk cave are nearly stable and calcite saturation index is function of cave air  $\text{CO}_2$  concentration.

Partial pressure of air  $\text{CO}_2$  is fluctuated intra-daily and seasonally in Petruk cave and surface rainfall cools outside air temperature and inverse airflow direction. Therefore, that is trigger of  $\text{CO}_2$  concentration drop, which is driven by airflow direction inversion. It is considered that that  $\text{CO}_2$  drop by rainfall is the key of inverse-correlations between precipitation and  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values of speleothems.

We will show the relationships between cave air  $\text{CO}_2$  concentration fluctuation and stable isotope values of dripwaters in this poster.

Keywords: speleothem, carbon dioxide, precipitation, stable isotope

## Behavior of Uranium and Thorium isotopes in Darkhad basin, northern Mongolia

Takuma Murakami<sup>1\*</sup>, Masayoshi Yamamoto<sup>1</sup>, Madoka Fuchizaki<sup>1</sup>, Keisuke Fukushi<sup>1</sup>, Seiya Nagao<sup>1</sup>, Kenji Kashiwaya<sup>1</sup>

<sup>1</sup>Institute of Nature and Environmental Technology, Kanazawa University

Darkhad basin is located adjacent to Lake Hovsgol and occupies a southwestern part of the Baikal Rift Zone. In this area, the signals in response to insolation forcing in the lacustrine sediments have been found in vertical profiles of various components, such as diatom abundance (biogenic silica content), grain size, organic carbon content and elemental concentrations. In particular, it is known that uranium (U) is one of the most important chemical indexes in Lake Baikal and Lake Hovsgol. Previous studies have reported that U (authigenic U) concentration in sediment increases during the interglacial periods and decreases during the glacial periods. Therefore, many researchers have pointed out a possibility that the variation can be used as a paleoenvironmental indicator. In this study, we analyzed U and Th isotope concentrations in sediment core (DDP10-3) of Darkhad basin to discuss the depositional process and the possibility as a paleoenvironmental indicator.

Core DDP10-3, 164.5 m long, was collected at 51°19'51.20"N, 99°30'4.40"E in Darhard basin in the spring of 2010. The core was cut into 3 cm thick for the entire length. In this study, sub-samples were selected each ca. 1 m intervals for U and Th isotopes analysis. Their sub-samples were freeze-dried and homogenized. Each 0.5 g dry sediment sample was calcined overnight at 450 °C, and then decomposed with open system wet method using HNO<sub>3</sub>-HF-HClO<sub>4</sub> and fusion with Na<sub>2</sub>CO<sub>3</sub>. Concentrations of U and Th isotopes were determined by alpha-particle spectrometry, after eluting U and Th from other elements using anion exchange resin. At August 2011, we collected twelve water samples at eight inflow and one outflow rivers in Darkhad basin for information on <sup>238</sup>U concentration and <sup>234</sup>U/<sup>238</sup>U activity ratio. The U isotopes concentration in river water samples was analyzed by the above method.

Dissolved <sup>238</sup>U activity concentrations and <sup>234</sup>U/<sup>238</sup>U activity ratios in the river water show a range from 3 to 50 mBq/L and from 1.5 to 5, respectively. The concentration and ratio of inflow rivers are classified into the three types according to influx route (southern, western and eastern routes of Darkhad basin). Each concentration and ratio of southern, western and eastern inflows is 50 mBq/L and 5, 3 mBq/L and ca. 1.5, and 3-12 mBq and 1.7-2.6, respectively. A major factor in this difference is considered to be due to the geological setting around Darkhad basin. Concentrations of <sup>238</sup>U and <sup>232</sup>Th in sediment samples vary in a range from 10 to 83 mBq/g and from 9 to 70 mBq/g, respectively. The <sup>234</sup>U/<sup>238</sup>U ratios range from ca. 1 to 2 and show mainly close to 1 throughout the whole core. The high <sup>234</sup>U/<sup>238</sup>U ratios (> 1) were observed at about 140 m, 72 m and 27 - 37 m core depths. These high <sup>234</sup>U/<sup>238</sup>U ratios indicate the presence of some authigenic U in the bulk sediments. There are the authigenic U in the interval of absence of carbonate minerals. In the conference, we will discuss about the depositional process of U and Th isotopes.

Keywords: Uranium-Thorium, Northern Mongolia, Continental Asia, paleo-climate change

## Environmental changes on the southern Kyushu over the last 30 ka reconstructed from the sediments of Lake Imuta-ike

Kazuyoshi Yamada<sup>1\*</sup>, YOSHITSUGU SHINOZUKA<sup>2</sup>, Koji Seto<sup>3</sup>, Tsuyoshi Haraguchi<sup>4</sup>, Ryusuke Imura<sup>5</sup>, Hitoshi Yonenobu<sup>6</sup>

<sup>1</sup>Waseda University, <sup>2</sup>Hokkaido University, <sup>3</sup>Shimane University, <sup>4</sup>Osaka City University, <sup>5</sup>Kagoshima University, <sup>6</sup>Naruto University of Education

We present paleo-environmental record on the southern Kyushu area, from the geochemical evidences for sediment core of Lake Imuta-ike, Kagoshima Prefecture over the last 30,000 years.

Lake Imuta-ike, is a volcanic crater lake, located on the southern part of Kyushu Island. The lake serves a protected natural habitat of rare animals, and is a registered wetland under the Ramsar Conservation. The environment of the lake and its vicinity is of particular importance, because there have been no geological studies so far.

We collected 25-m length sediment cores from bottom of the lake in February 2011. Using the core, we had firstly undertook a series of analysis, e.g., lithological observation, non-destructive X-ray CT scanning, identification of tephras, <sup>14</sup>C dating and sequential measurements of physical properties and magnetic susceptibility. By these analysis, we could build up the stratigraphy and the precise chronology of the core.

For reconstructing past environmental changes over the last 30,000 years, we measured total organic carbon (TOC), total nitrogen (TN), and total sulfur (TS) contents by CNS element analyzer as well as major and trace elements by ICP-AES with 2.3-cm interval bulk samples through the core.

As the results, in the last glacial after 30,000 cal yr BP, the proxy records of detritus inputs by climate changes have fluctuated with millennial scale and temporally increased at the periods of 27, 25-24, 22-21, 19-18, and 16 cal kyrs BP. These climate cool/dry events could be compared with the stadials in the North Atlantic region such as the Heinrich events. During the last glacial-interglacial transition (the LGIT, 15-9 ka), corresponding periods to the Younger Dryas (YD) stadial are identified as cold climate condition from 14.5 to 12.0 cal kyrs. In the Holocene, three large change of proxy records was occurred at 8,000, 4,000 and 2,000 cal yr BP.

Keywords: lake sediments, Geochemistry, LGIT, the Southern Kyushu

## The formation process of the lamina in sediments of Lake Abashiri, North Japan

Koji Seto<sup>1\*</sup>, Kota Katsuki<sup>2</sup>, Takeshi Sonoda<sup>3</sup>, Toshihumi Kawajiri<sup>4</sup>, Takaaki Watanabe<sup>5</sup>

<sup>1</sup>ReCCLE, Shimane Univ., <sup>2</sup>KIGAM, <sup>3</sup>Tokyo University of Agriculture, <sup>4</sup>A fishermen's cooperative association of West Abashiri, <sup>5</sup>Abashiri City

Lake Abashiri in the eastern part of Hokkaido is connected with the Sea of Okhotsk through Abashiri River. The water column of Lake Abashiri has a distinct halocline around 5m depths, and is divided into oligohaline epilimnion and polyhaline hypolimnion by metalimnion (halocline). The hypolimnion in Lake Abashiri shows the euxinic conditions throughout the annual. For eutrophication, the epilimnion is often observed the blooming of phytoplankton. In spring season (ice melting season) and late summer season (flood season), high turbidity river water is flowing from the Abashiri River.

The sediment of Lake Abashiri is observed a lamination by soft-X ray photograph. The 10AB-5C core, collected from 15.9 m of water depth in the center of Lake Abashiri, is composed of muddy sediment with a distinct lamination through all horizons. Result of observation of soft-X ray photograph, the lamina set of high-density layer, low-density layer, and intermediate-density layer are recognized. The Ta-a tephra (AD 1739) and Ko-c2 tephra (AD 1694) are found at the horizon of 250 cm, and 291 cm, respectively. Sedimentation rate based on these ages was 0.92cm/yr between Ko-c2 tephra and Ta-a tephra, and was 0.91cm/yr between surface and Ta-a tephra. Lamina set of 44 was recognized between Ko-c2 tephra and Ta-a tephra. This is suggested that this set is annual lamina. If so, high-density layers of lamina set are indicated the flood season from the patterns of precipitation in Abashiri Area. When distinct floods have been recorded, high-density layer is clear and thick. High-density lamina set series and low-density lamina set series are repeated in 20-30 year cycle. High-density lamina set series corresponds to the period of continuously high precipitation. This is suggested that high-density layer indicate the flood season in late summer.

In order to clarify the formation process of the lamina set in Lake Abashiri, we are observed by a sediment trap. Sediment traps are set up above 2m from lake bottom in water mass under euxinic environment. Result of this observation, sediment flux is increased in early spring (ice melting) and late summer (flood) seasons. Sediment flux in early spring season is higher than late summer season. Total organic carbon (TOC) contents of trapped sediment are higher than surface sediments except for trapped sediment in early spring season. These are suggested that low-density layer indicate in early spring (ice melting) season. In winter (ice) and early summer seasons, the sediment flux is low, and TOC contents show the high value. This is suggested that the limited supply of inorganic sediment. In this time, the diatom lamina may be formed in lamina set.

Keywords: Lake Abashiri, euxinic environment, lamina set, varve, Sediment trap, Total organic carbon contents

## Stratigraphy and lithologic features of the drilling cores from Lake Inawashiro, Tohoku, Japan.

Kotaro Hirose<sup>1\*</sup>, Yoshitaka Nagahashi<sup>1</sup>

<sup>1</sup>Fukushima University

Lake Inawashiro successively remains paleoenvironmental records -climate changes, volcanic activities, and anthropogenic activities-. In this study, sediment cores are obtained from the vicinity of the depocentre of the lake, 90 m in water depth. Parallel sets of the two cores (INW2012-1 and 2) are recovered for complete records, and integrated by correlation of the lithological features.

INW2012 is sectionalized into two units (Unit 1 and 2). We report the detailed lithological features, dating and preliminary result about chemical components and diatom assemblages in the lecture.

Keywords: Lake Inawashiro, lithostratigraphy, tephra, Paleoenvironmental change, diatom assemblage, chemical components



## Sedimentary record of historic earthquake in Lake Inawashiro, Japan

Katsuhiko Nameki<sup>1\*</sup>, Yoshio Inouchi<sup>2</sup>, Yoshitaka Nagahashi<sup>3</sup>, Kotaro Hirose<sup>3</sup>

<sup>1</sup>Graduate School of Human Sciences, Waseda University, <sup>2</sup>Faculty of Human Sciences, Waseda University, <sup>3</sup>Faculty of Symbiotic Systems Science, Fukushima University

Lake-bottom drilling at the central part of Lake Inawashiro was carried out by the member of Fukushima University in the fall of 2012 and about 30m long sediment was recovered. We analyzed uppermost 1.3m sediment and some event layers were correlated to historic earthquake events.

The sediment was composed chiefly of dotted greenish grey silty clay intercalated by thinly banded dark layers. Brownish grey silty layer is intercalated at depth of 35 to 40cm. Soft X-ray photo shows several dark layers which imply less transparency of soft X-ray. Sediment samples were taken at each 5mm depth and analyzed water content and grain size were measured at 1cm interval. The result shows existence of several event layers which show lower water content and coarser grain size. At depth of 35 to 40cm volcanic mudflow sediment of 1888 Bandai eruption was recognized. Mass sedimentation rate was measured based on the age of volcanic mudflow and sedimentation age of event layers were estimated. The result shows existence of event layers of 2011 large earthquake and 1943 Tajima earthquake.

Keywords: Lake Inawashiro, event layers, historic earthquake

## Lake-level changes and their factors during the last 45,000 years in Lake Nojiri, Central Japan.

Yuki Nakamura<sup>1\*</sup>, Yoshio Inouchi<sup>2</sup>, Takahiko INOUE<sup>3</sup>, Yoichi Kondo<sup>4</sup>, Fujio Kumon<sup>5</sup>, Yoshitaka Nagahashi<sup>6</sup>

<sup>1</sup>Atmosphere and Ocean Research Institute, The University of Tokyo, <sup>2</sup>Faculty of Human Sciences, Waseda University, <sup>3</sup>Natural Institute of Advanced Industrial Science and Technology, <sup>4</sup>Nojiriko Museum, <sup>5</sup>Faculty of Science, Shinshu University, <sup>6</sup>Faculty of Symbiotic Systems Science, Fukushima University

Stratigraphic analysis of acoustic records revealed that lake-level fluctuation repeated eight times in Lake Nojiri, Central Japan, during the past 45,000 years. Comparison of the lake-level record among profiles of pollen composition, TOC concentration both in Lake Nojiri, oxygen isotope record of NGRIP and those of Sanbao/Hulu caves, shows the lake level rose during the abrupt cold stages. Especially, high lake levels correspond with the global cooling events such as Younger Dryas, Heinrich events etc. The factors for the lake-level rise during cold stages are, decreased evaporation due to cooling and increased snowfall due to enhanced winter monsoon.

Keywords: Lake Nojiri, lake-level fluctuation, acoustic record, cold events, snowfall

## Revision of age model for Takashima-oki drilling core, Lake Biwa, Japan

Yoshio Inouchi<sup>1\*</sup>, kazuyoshi yamada<sup>1</sup>, Makoto Okamura<sup>2</sup>, Hiromi Matsuoka<sup>2</sup>, Yasuhumi, Satoguchi<sup>3</sup>, Ryoma, Hayashi<sup>3</sup>, Hiroshige NEGAMI<sup>4</sup>, Takayuki, Murakoshi<sup>4</sup>, ryosuke okada<sup>5</sup>, Koki Matsuhisa<sup>5</sup>, Gaku Hashimoto<sup>5</sup>, Koji, Matsunoshita<sup>5</sup>, Takasuke, Akata<sup>5</sup>

<sup>1</sup>Faculty of Human Sciences, Waseda University, <sup>2</sup>Faculty of Science, Kochi University, <sup>3</sup>Lake Biwa Museum, <sup>4</sup>Graduate School of Human Sciences, Waseda University, <sup>5</sup>School of Human Sciences, Waseda University, <sup>6</sup>., <sup>7</sup>., <sup>8</sup>., <sup>9</sup>., <sup>10</sup>., <sup>11</sup>., <sup>12</sup>., <sup>13</sup>.

Several papers concerning paleoclimatic changes are published using Takashima-oki core taken in 1986 at the central part of Lake Biwa, Japan. Analysis with higher time resolution is being carried out. In that case more precise age control is essential.

We took three piston core sediments and obtained many samples for dating. Cored sample lengths were around 16 meters and oldest age at present is 45kaBP at 14.5m depth.

Correlation among cored sediments are based on the horizons of wide spread tephra and profiles of water contents which show fairly good correlation. On the other hand, based on carbon-14 ages, horizons of K-Ah and U-Oki tephra might need some revision. Further analysis of grain size and total carbon and total nitrogen contents will be carried out in order to obtain more detailed correlation with Takashima-oki cored sediment.

Keywords: Lake Biwa, sediment, Takashima-oki, age, paleoclimate, tephra

## Climate changes during the past 130 kyr based on biogenic silica record in Takashimaoki

Takayuki Murakoshi<sup>1\*</sup>, Hiroshige NEGAMI<sup>1</sup>, Yoshio Inouchi<sup>2</sup>

<sup>1</sup>Human Sci., Waseda Univ., <sup>2</sup>Fac. Human Sci., Waseda Univ.

Lake Biwa, located at the center of Japan, has a continuous sediment record during the last ca. 430,000 years. We restored paleoclimatic changes during the last 130,000 years around Lake Biwa based on the biogenic silica content (BSC) profile obtained through molybdenum yellow method. BSC record of Takashima-oki core shows similar variability of that of Marine Isotope record in addition to cold events of Heinrich events. Result of frequency analysis shows similar periodicity of D-O events and Milankovitch cycle.

Relatively warm stages in the profile of Takashima-oki core coincide fairly well with those observed in Japan Sea sediment as dark layers, in addition to those off Choshi of the Pacific Ocean. These results imply that paleoclimate changes around Lake Biwa was strongly controlled by the sea surface temperature changes around Japanese islands.

Keywords: Lake Biwa, BSC

## Flood sediment off rivermouth of Echi-gawa, Lake Biwa, Japan

Yoshio Inouchi<sup>1</sup>, Yasuhumi, Satoguchi<sup>2</sup>, Yuki, Nakamura<sup>3</sup>, Takayuki Murakoshi<sup>4</sup>, Gaku Hashimoto<sup>5\*</sup>

<sup>1</sup>Faculty of Human Sciences, Waseda University, <sup>2</sup>Lake Biwa Museum, <sup>3</sup>Atmosphere and Ocean Research Institute, <sup>4</sup>Graduate School of Human Sciences, Waseda University, <sup>5</sup>School of Human Sciences, Waseda University

Water content, grain size and total carbon and nitrogen content were measured with cored sediment taken by gravity corer off river mouth of Echi-gawa, at the south-eastern part of Lake Biwa, Japan. The result shows existence of event sediments which show characteristics of hyperpycnite.

Sediment cores were taken 1.5km off river mouth of Echi-gawa on 12th September 2011 and the length were 50cm and 69cm respectively. Water content was measured at each 1cm, grain size at each 5mm and total carbon and total nitrogen was measured at each 5mm depth. The result shows existence of several event layers which are dark in soft-X photos, lower water content, coarser grain size and higher content of total carbon and total nitrogen. Each event layers show reverse grading at bottom and normal grading on top, have several maxima in grain size and contain plant fragments.

Carbon-14 age at the middle part of B3 core was 50 to 100 yrs.BP. Consequently, the age of cored sediments is around 100 years BP. During the last 100 years several historic large floods are recorded, namely, large flood in 1896 and 1917.

Keywords: Lake Biwa, flood sediment, hyperpycnite

## Paleoclimate reconstruction for the past 120 kyrs based on pollen analyses using deep-sea sediments from the core C9001C

Manami Sugaya<sup>1\*</sup>, Masaaki Okuda<sup>2</sup>, Makoto Okada<sup>3</sup>

<sup>1</sup>Graduate School of Science and Engineering, Ibaraki University, <sup>2</sup>Natural History Museum and Institute, Chiba, <sup>3</sup>Department of Science, Ibaraki University

We used pollen analysis for a marine core to obtain a paleoclimate record with the Milankovitch time scale. In this study, we obtained a continuous pollen record and reconstructed paleovegetation and paleoclimatic variations for the past 120,000 years from the core C9001C, drilled off Shimokita Peninsula.

We have done pollen analyses for 48 horizons from Holocene to MIS 5e, and defined four vegetation zones from the pollen assemblages as follows. Zone 1 (MIS5e) ; temperate deciduous forest zone dominated by *Quercus* *Lepidobalanus* and *Fagus*. Zone2 (-a, -b, -c, -d) ; (MIS5d~5b); transitional zone between Zone 1 and 3 characterized by increased conifer trees such as *Abies*, *Tsuga*. Zone3 (MIS4~MIS2) ; cool mixed forest zone dominated by *Picea* and *Betula*. Zone4 (MIS1 to the present) ; temperate deciduous forest zone. These temperate and cool mixed forest pollen assemblages are quite comparable with the present vegetation at northern Japan and lowland area of Hokkaido, respectively.

We have applied the Modern Analogue Method to the pollen assemblages to reconstruct quantitatively paleoclimatic variations. As the results, reconstructed paleotemperature obviously has a positive correlation with the glacial/interglacial cycles indicated by the oxygen isotopic record of the core. On the other hands, reconstructed summer precipitation, indicating a strong negative correlation with annual temperature differences, seems to be correlated with a summer insolation change. These results support a hypothesis to explain the East Asia monsoon fluctuation from the Lake Biwa pollen record.

Keywords: pollen analysis, glacial/interglacial, quantitative reconstruction, East Asia monsoon

## Paleoclimate reconstruction based on pollen records from Late Pleistocene non-marine sequence in the Ibaraki Prefecture

Yuto Ikeda<sup>1\*</sup>, Makoto Okada<sup>2</sup>, Manami Sugaya<sup>1</sup>, Shinzou Ooi<sup>1</sup>

<sup>1</sup>Graduate school of Science and Engineering,Ibaraki University, <sup>2</sup>Department of Science,Ibaraki University

The purpose of this study is to reconstruct quantitatively a past climate during Marine Isotope Stage(MIS)6~5e in Ibaraki Prefecture by using pollen analysis.

Samples for pollen analysis were collected from 47 horizons at three locations in Ibaraki Prefecture. As a result of speculum and pre-treatment, we could find enough number of pollen grains from 14 horizons at one location. Fossil pollen and spore from those horizons that we identified were 33 taxa in total.

By using the modern analogue method to the results, we reconstructed three paleoclimate parameters (TANN:annual temperature, MTWA:mean temperature of the warmest month, MTCO:mean temperature of the coldest month). All reconstruction results show downward trend with each age, the paleoclimate of about 130 ka in Namegata,Ibaraki Prefecture was became clear that similar to present climate of Hokkaido and Sakhalin. However, this results was inconsistent with the opinion that layer of this study is deposit of transition to interglacial from glacial. The reason of this absurdity was presumed that reconstruction results of this study was paleoclimate of cooling short event in transition to interglacial from glacial.

Keywords: Pollen analysis, Paleoclimate, MIS 6/5 boundary

## The study on the paleosols in the Tokiguchi Porcelain Clay Formation at Hishiya Mine in Toki, central Japan.

Nozomi Hatano<sup>1\*</sup>, Kohki Yoshida<sup>2</sup>

<sup>1</sup>Division of Science and Technology, Graduate School of Shinshu University, <sup>2</sup>Department of Geology, Faculty of Science, Shinshu University

The Seto Group, which is known as fluvial deposits distributed in central Japan in Miocene-Pliocene period, is divided into two formations as the Tokiguchi Porcelain Clay and the Toki Sand and Gravel Formations in ascending order (Akamine, 1954). The Tokiguchi Porcelain Clay Formation was researched from a point of view of clay mineralogy to clarify the factor in clay formation process (e.g., Kitazaki and Araki, 1952; Nozawa, 1953; Tanemura, 1964; Fujii, 1967) and sedimentology to demonstrate the depositional environment of clay deposition (e.g., Nakayama, 1991; Saneyoshi et al., 2000; Nakajima et al., 2004). But no precedent to assess environment of clay deposition both by clay mineralogy and sedimentology. This study aims to reconstruct detailed environment from paleopedology and to analyze clay minerals assemblage using a x-ray diffractometer. In addition, the attendant objective of this study is to demonstrate weathering condition of the Tokiguchi Porcelain Clay Formation. For this purpose, the Hishiya Mine in Toki City, Gifu prefecture, was selected as a study area.

On the sedimentary facies analysis, 12 facies are divided in this formation. These facies include the depositional environments mainly in backswamp with minor channel incision. Besides, 10 paleosol horizons can be recognized in the backswamp deposits.

These paleosol horizons contain various pedogenic features, such as root traces, pedogenic concretions, ped structures and microfabric of clay minerals. These paleosols are considered to have been formed in three different parts in the backswamp environments as follows: 1) deposits characterized by few root fossils and lack of microfabric of clay, with gray - blue soil colors, indicating water-saturated condition, 2) deposits containing limonite concretion and mottling by oxidized iron with reddish brown color indicating better-drained condition, 3) deposits including many root fossils, pyrite nodules, remarkable microfabric such as illuviated clay in cavity, slickensides and ped structure indicating oscillation in hydrological condition.

Clay mineral analysis focused on <2.0 micrometer size fractions was performed using ethylene glycol treatment, heat treatment, hydrochloric acid treatment and potassium chloride treatment. As a result, the clay mineral assemblage is composed of kaolinite, Al-vermiculite and mica minerals. There are no significant variation in clay mineral assemblage of the backswamp deposits. It is possible that acidic condition was prevailed in soil from sedimentation to earliest diagenetic stage, because the backswamp deposits contain a large amount of organic material as coal horizons and root fossils. Kaolinite and Al-vermiculite are thought to have been crystallized by weathering on the acidic soil condition.

As a result, The Tokiguchi clay formation was deposited in backswamp environments along river system. The soil condition in backswamp deposits was affected by oscillated water table and an abundance of organic carbon material, which possibly contributed to the concentration and crystallization of clay minerals in the Tokiguchi Porcelain Clay Formation.

Keywords: Tokiguchi Porcelain Clay Formation, Depositional environment, Paleosols, Weathering, Clay mineral assemblage



## Temporal change of the sources of Aeolian dust delivered to East Asia revealed by ESR signal and Crystallinity Index

Yuya Yamamoto<sup>1\*</sup>, Shin Toyoda<sup>1</sup>, Kana Nagashima<sup>2</sup>, Yasuhito Igarashi<sup>3</sup>, Ryuji Tada<sup>4</sup>

<sup>1</sup>Okayama University of Science, <sup>2</sup>Japan Agency for Marine-Earth Science and Technology, <sup>3</sup>Metrological Research Institute, <sup>4</sup>The University of Tokyo

Change of atmospheric circulation system in the past is an important issue for studies of paleoclimate. Aeolian dust, fine particle suspended in air and brought by wind, is a clue to know the wind direction and the strength in the past. Historical record of aeolian dust accumulation in Japan will give important information on this issue as well as on the climate change in the arid source regions in China. Various features, such as grain size distribution, mineral compositions, and isotope compositions, have been investigated for loess sequence for this purpose. In the present study, we would like to propose that ESR signals in quartz are other good proxies as well.

We observe the signals of the  $E_1'$  center, an unpaired electron trapped at an oxygen vacancy. It was shown previously that, by measuring the number of oxygen vacancies, as evaluated as the heat treated the  $E_1'$  center, in loess sequence, the aeolian dust source in Holocene was different from that in LGM (Toyoda and Naruse, 2002). Later, the crystallinity index was found to be another proxy for such studies. Temporal change of the origins of the eolian dust accumulated in the Sea of Japan was found to be correlated with the climate change by using crystallinity index and the number of oxygen vacancies (Nagashima et al., 2007).

The samples of monthly atmospheric deposition (total deposition = wet + dry) were collected for a month in a 0.5 m<sup>2</sup> plastic open surface collector installed in the observation field of the meteoritic observatories at Fukuoka and at Akita for one month. The collected samples in the container were heated to evaporate out the water. Meteorological Research Institute offered the atmospheric depositions collected in March and in June in 1964 to 2000 for the present study. Samples of fine grain river sediment were also collected at Fukuoka and at Akita

The temporal changes in the number of oxygen vacancies in quartz of atmospheric depositions collected at Akita and at Fukuoka were investigated. The temporal change of the number in the sample collected at Fukuoka in March is correlated with the total Kosa days, while no correlation was found in Akita but gradual decrease with age. The number of oxygen vacancies in quartz in the atmospheric deposition might be an indicator to estimate quantitatively the contribution of the dust originated from Chinese to the atmospheric deposition. The difference between Fukuoka and Akita would imply possible difference in mode of transportation of the dust to these two cities.

Keywords: ESR

## Temperature changes of shallow waters during the late Pliocene in the Sea of Japan based on Mg/Ca of ostracode shells

Katsura Yamada<sup>1\*</sup>, GOTO, Takashi<sup>2</sup>, IRIZUKI, Toshiaki<sup>2</sup>

<sup>1</sup>Shinshu University, <sup>2</sup>Shimane University

Mg/Ca analysis of ostracode shells were conducted by using genus *Krithe* (intermediate water dweller) and *Cytheropteron* (shallow water dweller) in the Kuwae Formation, central Japan to determine more accurately the paleo-temperatures of intermediate and shallow waters during the late Pliocene in the Sea of Japan. More than 60 sandy mudstone samples were collected from Tainai and Sakai sections where the upper Pliocene Kuwae Formation well exposed. Two to six whole ostracode valves per sample were analyzed by ICP-AES in Kochi Core Center. The regression lines established in the previous studies (e.g. Dwyer et al., 2002) were used for *Krithe*. For *Cytheropteron*, the partition coefficient between water temperature and Mg/Ca ratio of ostracode shells was newly established based on the analysis of recent ostracode shells collected from the Sea of Japan.

Calculated bottom water temperatures located under intermediate waters ranged from 0.5 to 15 degrees C in the Tainai section. Their intervals in each sample ranged from 2.0 to 7.5 degrees C based on seven different regression lines. The intermediate water temperature shifted largely and abruptly with the range more than 5 degrees C in interglacial periods, whereas it changed within the range less than 3 degrees C in the glacial periods. During the MIS G17, lowest temperature (0.5-3 degrees C) was estimated in the interglacial maximum. Moreover, two peaks of higher temperature (6-10 degrees C) were found in the horizons just below and above the interglacial maximum, which correspond to the transitional periods. Therefore bottom water temperatures in the study site increased in the transitional period from glacial to interglacial maximum due to the inflow of the Temperate Intermediate Waters (TIW) though water depth became deeper. Then, the study site was influenced by cold deep waters lying under the TIW due to sea-level rise at the interglacial maximum. Increase and decrease of intermediate water temperatures during the transitional period from interglacial to glacial maximum indicate that the study site was deposited under the TIW again and then was affected by cool intermediate waters after the disappearance of the TIW. Steady temperatures during the glacial periods may attribute to a good balance between temperature decrease due to a climate cooling and its increase induced by sea-level drop. Shallow water temperature calculated by Mg/Ca ratio of valves of *Cytheropteron* ranged between 7 and 14 degrees C in the Tainai section. Relatively higher values (10-15 degrees C) were estimated in the horizons corresponding to glacial and interglacial maximum. Paleo-temperature gradient between shallow and intermediate waters were reconstructed based on our calculated temperatures of Mg/Ca records in the periods of the MIS G19 to G17 and G14 to G13 in the Sea of Japan. The estimated values of intermediate water in the MIS G17 and G13 were within the temperature that *Krithe* can inhabit abundantly in the recent sea around Japan. They are approximately 4-6 degrees C warmer than those at water depths of 150-200 m off the study site today.

Intermediate waters ranged between 0 and 8 degrees C in the Sakai section. Two lower and higher values of intermediate water temperatures were recognized in the horizons corresponding to shallow and deep environments based on ostracode assemblages, respectively. On the other hand, shallow water temperatures shifted more frequently within intervals of 5 degrees C. Thus, difference in shifted patterns of intermediate water temperatures corresponding to glacial and interglacial cycles was appeared between in the Sakai and Tainai sections. Fossil ostracode analysis and sedimentary facies infer that depositional environments in the Sakai section were shallower than those in the Tainai section. This might be caused their distinctions.

Keywords: Sea of Japan, Late Pliocene, Ostracod, Mg/Ca, Paleo-water temperature

## Reconstruction of SST Front behavior in the Japan Sea during the Holocene based on Alkenone paleothermometer

Masahito Abe<sup>1</sup>, Masanobu Yamamoto<sup>2</sup>, Ryuji Tada<sup>1\*</sup>, Takuya Itaki<sup>3</sup>, Kazuho Fujine<sup>1</sup>, Kana Nagashima<sup>4</sup>, Masao Uchida<sup>5</sup>

<sup>1</sup>Department of Earth and Planetary Science, The University of Tokyo, <sup>2</sup>Faculty of Environmental Earth Science, Hokkaido University, <sup>3</sup>National Institute of Advanced Industrial Science and Technology, <sup>4</sup>Japan Agency for Marine-Earth Science and Technology, Research Institute for Global Change, <sup>5</sup>Center for Environmental Measurement and Analysis, National Institute for Environmental Studies

The Japan Sea is a semi-enclosed marginal sea connected to the North Pacific and adjacent marginal seas through four shallow and narrow straits. The Tsushima Warm Current is the only current flowing into the Japan Sea and plays an important role on controlling the environment of the sea by supplying heat, salt and nutrient. Strong north-south Sea Surface Temperature(SST) gradient zone is formed around longitude 40 degrees north in the Japan Sea, and is defined as the SST front. The position of the SST front varies with the depth of the sea. Especially, the boundary between the Tsushima Warm Current and Liman Cold Current, which is defined at 100m depth, is named Sub-Polar Front (SPF).

Choi et al. (2012) reconstructed spatial and temporal changes of the alkenone SST in the Japan Sea during the last 130 ka, and attempted to reconstruct the behavior of the SST front. However, their studies lack information on the central part of the Japan Sea, which is the best place to monitor the position of the past SST front. This study aims to examine past behavior of the SST front position in the central part of the Japan Sea during the Holocene based on the reconstruction of alkenone SST using the 3 cores forming the latitudinal transect in the south central part of the Japan Sea. Reconstructed alkenone SST of PC-8 core located in the central part of Yamato Bank were compared with those of MD01-2407 at Oki Ridge and ODP797 (Xing et al., 2011) from the southern part of the Japan Sea to figuring out the difference in temperature between the north and the south during the Holocene. To identify the water depth and specific season at which the alkenone SST is recorded, I compiled and reexamined a 1-year long time series data-set of the monthly alkenone flux and the sea water temperature at various depths in the Japan Sea (Lee et al., 2011). Based on careful examination of these data, I concluded that the flux-weighted alkenone SSTs at the two sites are close to the temperature at 0-10 m depth during spring to summer.

Reconstructed alkenone SST from the northernmost site (PC-8) in the central part of the Japan Sea show an increasing trend from 10 degrees Celsius to 16 degrees Celsius between 11.1ka and 7ka. On the contrary, reconstructed alkenone SST from the central (ODP797) and southernmost sites (MD01-2407) show more or less constant temperatures around 16 degrees Celsius at the central site and 18 degrees Celsius at the southernmost site after 10ka. North-south alkenone SST difference between the northernmost and southernmost sites was about 7 degrees Celsius in the early Holocene. However, the difference became smaller (ca.2 degrees Celsius) in the middle Holocene (5ka). Comparison with the modern SST distribution from north to south suggests that past SST front was located 2 degrees to the south, and shifted northward during the early to middle Holocene. A possible explanation for this northward shift of the SST front is an increase in volume transport of the third branch of the Tsushima Warm Current. The idea is supported by the observation that radiolarian fossils typical for East China Sea gradually increase after 8ka. Therefore, northward shift of the reconstructed SST front at 10 m depth during spring to summer represents northward shift of the SPF.

## Characteristics of periodicities exhibited in the major elements' variation of the late Pleistocene Japan Sea sediments

Tomohisa Irino<sup>1\*</sup>, Ryuji Tada<sup>2</sup>

<sup>1</sup>Faculty of Environmental Earth Science, Hokkaido Univ., <sup>2</sup>Faculty of Science, Univ. of Tokyo

Major element composition of marine sediment is generally controlled by the mineral composition that is also affected by sorting effect during their transport process. This feature can be used for the variability of provenance and transport pathway of detrital fraction in the sediments of the Japan Sea. Detrital fraction in the sediments collected from the abyssal part of the Yamato Basin in the Japan Sea has been regarded as the mixture of eolian dust and the detritus derived from the Japan Arc.

Eolian dust source for the Japan Sea sediments is desert and loess area of the inland China. Loess can be classified into two types based on their major element composition. One is distributed close to desert area and called typical loess. The other is peripheral soil (weathered loess) distributed surrounding typical loess and desert area. Weathered loess is distributed in the north-eastern and southern China. We conducted spectral analysis for the temporal variations of winter and summer monsoon intensity deduced from contribution of typical and weathered loess, respectively, to the Japan Sea sediments. Typical loess contribution shows 100ky, 41ky, and 23ky periodicities widely known as the Milankovitch bands. On the other hand, Weathered loess contribution shows 41ky obliquity cycle as well as 293ky, 55ky, 32ky, and 27ky.

Detritus from typical loess is major part of eolian dust transported to the Japan Sea. In general, amount of dust transported to down wind is controlled by dust availability (aridity) of source area or length of dust season. Both require a southward migration of summer monsoon front which is nearly equal to the summer position of westerly jet suppressing the precipitation inland China and keeping a long lasting dust season (spring-like condition), which indicates weaker summer monsoon. Possible mechanisms to transport weathered loess to the Japan Sea are northwesterlies during winter or southward migration of westerlies main axis. Both phenomena require the stronger Siberian High during winter, which indicates stronger winter monsoon. Coherent 41 ky cycle seen in both typical and weathered loess suggests the latitudinal position of westerly is highly responsible for the East Asian monsoon. Trade-off relationship between winter and summer monsoon intensities is expressed only in this periodicity. Lack of common periodicities other than 41 ky suggests that winter monsoon behaves independently of summer monsoon in the East Asia.

Keywords: Japan Sea, Sediment, ODP Site 797, major element, periodicity