The potential for a high-resolution, Quaternary paleo-observatory network in the Japan, Yamato, and Ulleung Basins

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The Quaternary hemi-pelagic sediments of the Japan, Yamato, and Ulleung (JYU) basins are characterized by centimeter- to decimeter-scale alternations of dark (org-C rich) and light (org-C poor) clay to silty clay that are known to reflect variations in the East Asian summer monsoon (EASM) in association with millennial-scale abrupt climatic changes known as Dansgaard-Oeschger Cycles (DOC). These dark layers can be traced across the deeper (>500 m water depth) parts of the JYU basins, and therefore can be used as synchronous markers.
In the summer of 2013, IODP Expedition 346 drilled 7 sites in the JYU basins, and the 6 sites deeper than 800 m water depth are characterized by dark and light layering. Intercalation of the dark layers show millennial-scale variations in dark and light layers started *c.* 1.45 Ma with over 250 dark layers deposited repeatedly since then. In addition, approximately 100 tephra layers have been correlated across these 6 sites, and as a result we have obtained over 300 time slices with an average resolution of 5 k.y. covering the entire JYU basins.
We have constructed an age model for the Quaternary interval at Site U1424 off Akita using 10 geomagnetic polarity boundaries and 12 marker tephra layers as time constraints. This was then tuned using the gamma ray attenuation density (GRA) profile, which reflects diatom abundance, to the LR04 $d^{18}O$ stack to develop an age model of higher resolution and precision. This high-resolution and high-precision age model is projected to the other 5 sites using the correlation of dark layers and tephra layers. In this way, we have constructed a high-resolution paleo-observatory network from which to assess leads and lags in northern hemisphere climate. We will present a few examples of how to utilize the network.

Keywords: High-resolution, Quaternary, paleo-observatory network, IODP Expedition 346

Marine tephras in cores obtained by IODP Expedition 346: Stratigraphy, chronology and correlation

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Mary tephra beds are intercalated in marine sediment sequences around the Japanese islands. During IODP Expedition 346, the sediment cores were obtained from 7 sites in the Japan Sea and 2 sites from the northern East China Sea. Many tephra beds are observed in the cores from these sites. Several tephras were correlated to the age-known widespread tephras in Pliocene-Quaternary age, and some were used for inter-core and inter-site correlation. Results clearly indicate the importance of marine tephra study for establishing stratigraphy, chronology and correlation.

Keywords: tephra, IODP, stratigraphy

Oxygen isotope stratigraphy for the Japan Sea during the last 1 Myr using shallow marine sediment at IODP Site U1427

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The Japan Sea is sensitive to the glacial-interglacial sea level variation because of narrow and shallow straits, which connect with adjacent seas. The oxygen isotope change in the Japan Sea is, therefore, distinct from so-called “standard isotope curve.” While previous studies have tried to construct unique isotope stratigraphy for the Japan Sea using deep sea sediments, it is problematic that foraminiferal fossil do not occur continuously in the deep sea sediment due to significant change in paleoceanographic environment. Moreover, determination of marine isotope stages using planktonic isotope is not straightforward because lighter peaks correspond to both glacial and interglacial maxima.
The 570 m long sediment core is drilled during IODP Expedition 346 from ~330 m seafloor (Site U1427) off Tottori Prefecture. The sediment at this site lacks dark-light alternation, which generally observed in sediment from deep sites, indicating that the deep sea anoxic events at glacial maxima did not affect the depth of U1427. Therefore, well preserved benthic foraminifera are continuously observed except for some intervals. Here we analyzed benthic foraminiferal isotope at 1 m intervals in order to construct isotope stratigraphy for 1 Myr. Fortunately, the bottom water at the depth of U1427 is affected by surface freshening event at glacial maxima but not affected by Tsushima Warm Current at interglacial maxima. Therefore, the lighter value of benthic oxygen isotope reflects the glacial freshening event. The interglacial maxima are recognized by occurrence of warm water species of Radiolarians. By combining with tephrochronology, we have constructed oxygen isotope stratigraphy for 1 Myr.
Benthic foraminifera as well as calcareous nannofossils and ostracods are absent at intervals of MIS12 and 16. Because diatom species that prefer low salinity water are observed in these intervals, surface water freshening at these glacials were more severe than other glacials for benthic foraminifera.

Keywords: Japan Sea, isotope stratigraphy, glacial-interglacial cycle, Integrated Ocean Drilling Program

Paleoceanographic implications of radiolarian fossil assemblages in sediments from shallow water depths

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Radiolarian fossil analyses have been usually carried out using materials from deep-sea sediment sample, which is expected abundant occurrence of their fossils. However, if the condition is better, radiolarian fossils can be preserved even in the near shore sediments from shallow water depths. Such radiolarian assemblages from the shallow waters provide important information about paleoceanographic condition.

Radiolarian fossils can be used as indicators of surface and deep-water environments because of their discrete living depths for each species. In the present day, radiolarian assemblages in the Japan Sea are characterized by warm water species in shallow depths related to the Tsushima Current, while the cold-water species dominates in intermediate and deep waters related to the Japan Sea Proper Water [JSPW]. However, there is no guarantee that their depth zonation was same as the present day from analysis based on deep-sea sediments. On the other hand, radiolarian assemblages in sediments from shallow depths must be composed of only shallow dwellers, and doesn't include deep dwellers. Therefore, it is expected that comparison of radiolarian assemblages between deep-sea and shallow water sediments provide us important information about the past depth zonation of radiolarians.

IODP Site U1427 is located at 330 m water depth in the Japan Sea off Tottori, southwestern Japan. In this site, abundance of *Cycladophora davisiana*, which is a deep dwelling species related to deeper than 1,000 m of the present JSPW, increased during some intervals including MIS-12. This means that habitat depth of this species had shifted to shallower than 300 m in these periods, probably related to declined ventilation with low salinity surface water.

Keywords: Coastal environment, Tsushima Current, Japan Sea Proper Water

High-resolution XRF core scanner analysis of the Japan Sea sediments (IODP U1425) and its paleoceanographic implication

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Quaternary hemipelagic sediments of the Japan Sea have distinct dark and light layers, and these layers are correlated with Dansgaard-Oeschgar cycles (Tada et al., 1999). Previous studies revealed that these dark and light layers are characterized by variations of organic content and C/S ratio, the latter reflecting sea floor redox state, calcareous and siliceous production rates (Tada et al., 1999), and aolian dust and terrigenous fluxes (Irino and Tada, 2000; 2002) for last 200kyr. In the summer of 2013, IODP Exp. 346 drilled hemipelagic sediments of the Japan Sea, and revealed that these dark and light layers became distinct around 1.5 Ma (Tada et al., 2015). However, variability of these dark and light layers and other paleoclimate proxies with respects to their periodicities and amplitudes in association with Glacial-Interglacial cycles are not well studied because high-resolution quantitative analyses of thousands of samples generally require significant time and efforts. High-resolution and high-speed analytical methods are necessary with this regard so as to reveal millennial-scale variability of paleoclimate proxies during last 2.6Myr, entire Quaternary.
In this study, we conduct high-resolution, high-speed analysis of chemical composition using XRF core scanner (ITRAX) in CMCR (Center for Advanced Marine Core Research), Kochi University, to examine elemental variability in association with dark and light layers in the hemipelagic sediments of the Japan Sea. We used sediments recovered from Site U1425 located on Yamato Rise. We analyzed top ~100m of the sediments with 2mm resolution, and obtained elemental variability of entire Quaternary with 20 to 200 years resolution. In this presentation, we will show high-resolution reconstruction of burial rates of biogenic silica and carbonate, bottom redox state, aolian dust and terrigenous fluxes at the site during the entire Quaternary.

Keywords: XRF core scanner, Quaternary, dust, dark and light layer, redox, IODP Exp. 346

Assessment of time-dependent evolutionary rates of rodent mitochondrial DNA based on paleoclimatic calibrations of the Japanese Islands

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Use of the reliable time-dependent evolutionary rates of mitochondrial DNA might allow us to built realistic evolutionary scenario with phylogenetic inferences, covering a broad time scale based on the phylogenetic inferences. Other than using fossil evidence, it is possible to estimate evolutionary rates by relying on the well-established temporal framework of the Quaternary glacial cycles that would likely have promoted both rapid expansion events and interisland dispersal events. We are now focusing on the mitochondrial cytochrome *b* (*Cytb*; 1140 bp) sequences of a temperate species of wood mice (*Apodemus argenteus* and *A. speciosus*) from the Japanese Islands to assess evolutionary rates (site/million years) and obtained ca. 11% and 3% under assumption of rapid expansion and a priori information of the Quaternary climate fluctuation around 10 and 130 k years ago (ka), respectively (Suzuki et al., 2015). In addition, assuming that land-bridge like structures were created intermittently at glacial maxima of 100 k year intervals and shaped divergence patterns of the *Cytb* sequences of the larger Japanese wood mice *A. speciosus*, we obtained estimated evolutionary rates of 3.3 to 2.7% with presumed calibrations of 140, 250, 350 and 440 ka, through comparison of sequences from peripheral remote islands. In survey of rapid expansion signals in the lesser Japanese wood mouse *Apodemus argenteus* and three continental congeneric species from Asia and Europe, three levels of t values can be categorized into three levels, 3.9, 5.0-5.7 and 7.8-8.1. Adopting the idea in which the climate turned to be warm after preceded time of rapid cooling at 15, 53, 82 and 119 ka based on available pollen fossil evidence of trees including *Quercus* species, the evolutionary rates were estimated to be 11.4, 4.4-5.0, 3.1%, respectively. Here we propose the use of the time-dependent evolutionary rates (11~2.7%/site/million years) for the time span of 10 to 450 ka, hoping that it can be applicable to other species of murine rodents including mice and rats.
Reference: Suzuki Y, Tomozawa M, Koizumi Y, Tsuchiya K, Suzuki H (2015) Estimating the molecular evolutionary rates of mitochondrial genes referring to Quaternary Ice Age events with inferred population expansions and dispersals in Japanese *Apodemus*. *BMC Evolutionary Biology*, 15,187.

Keywords: mitochondrial DNA, evolutionary rate, Japanese Islands, Apodemus species, Quaternary glaciation

Optically stimulated luminescence dating back to 100ka and sedimentation rates of dark versus light layers in the Japan Basin

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Sediments in the Japan and Yamato Basins record millennial-scale changes in the East Asian Monsoon as alternations of dark and light layers. The gray-scale profile showing this millennial-scale variability has been correlated with the $d^{18}O$ record from Greenland ice cores (GISP2). However, this correlation between millennial and orbital scale changes becomes less certain during the last interglacial and the Holocene period, largely as a result of a paucity of biogenic carbonate used for ^{14}C and isotope stratigraphy; there is significant age uncertainty over this time period.
We have used optically stimulated luminescence (OSL) dating of fine-grained detrital quartz (that are aeolian in origin) to provide high-resolution numerical age models for cores U1424C and U1425C drilled in the southeastern margin of the Japan Basin, and the Yamato Rise, during IODP Expedition 346.

We report our attempts to: 1) assess whether surface sediment of the cores are consistent with modern age; 2) test the reliability of OSL ages by comparison with tephra chronology and orbitally-tuned age models based on the correlation between the GRA record and the LR04 stack; 3) date cores U1424C and U1425C to construct a robust 120 ky age model with a resolution of 10 ky; and 4) conduct high-resolution dating of several pairs of dark and light layers to estimate short term changes in sedimentation rate, in particular over the last ~30 ky. We show OSL dating of fine aeolian silt in Japan Sea sediments shows great potential to establish independent numerical chronologies, and this is especially useful in cores where isotope stratigraphies and/or gray-scale signatures are poorly reconciled.

Keywords: Optically stimulated luminescence dating , IODP Expedition 346, quartz

Is Central Europe the ‘witch's brew’ of Pleistocene paleoclimate studies? -The magnetic fabric approach

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The study of Pleistocene climate is one of the fastest growing disciplines in Earth Sciences. One of the best tools to obtain more information about the Pleistocene in terms of the terrestrial environment is the investigation of loess. The different varieties of loess together constitute one of the most widespread terrestrial sediments, which was deposited, altered, and redeposited in the course of the changing climatic conditions.
Central Europe is one of the most complex part of Europe from the sense of the present day’s climate conditions. The climatic components are influenced by all of the North Atlantic, Mediterranean (African) and Siberian (Asian) climate. The recent complexity arise a question about the Pleistocene paleoclimate of the area, and possibly makes it the ‘witch's brew’ of paleoclimate studies.
970 pieces of samples were taken from Paks profile (Central Europe, Hungary), one of the well-known sediment succession of the area, to reveal some component (e.g. wind direction) of the early Middle Pleistocene paleoclimate by anisotropy of magnetic susceptibility (AMS) measurements.
Weak anisotropy, quasi isotropic fabric and poorly defined orientation were revealed by the confidence ellipsoid of individual samples. Despite the character of individual samples, the ‘sample-populations’, related to various layers, had characteristic alignment on stereoplots. Proper changes of the basic AMS parameters (e.g. degree of anisotropy and shape of the susceptibility ellipsoid), were also identified in the profile.
Two main sedimentary environments were revealed by the AMS analysis. The homogeneous loess was characterized by well-defined horizontal foliation plane, strongly oblate (lentil shape) susceptibility ellipsoid. Weak, temporarily changing, W, NE and S(E) transport/deposition (wind) orientations were also defined, indicating influences of North Atlantic, Siberia and Western Asia respectively. The character of the fabric indicated low energy transport and relatively calm environment during deposition.
In contrast, the magnetic fabric of the moderately-poorly sorted, coarser, and partly fine laminated materials show higher variability. The fabric of the sandy aleurite and sand layers are characterized by oblate, triaxial and prolate (rugby ball -like) susceptibility ellipsoid either. Generally, these sediments have stronger anisotropy compared to the loess. AB plane imbrication and the influence of slope during deposition were revealed by the stereoplot analysis. The magnetic fabric, characterized above, suggests stronger, possibly water-lain transport processes and redeposition on slope. The quick changes of the paleoenvironment were indicated by the radical change of the orientation of the transportation in short geological period, and it could be induced by the rapid change of the paleoclimate.
Paleosol horizons, intercalated in sediments, were also observed. Based on the degree of the development and the structure of the paleosol, various magnetic fabrics are defined. Generally, the paleosols are characterized by oblate/triaxial susceptibility ellipsoid and weak anisotropy. Horizontal and quasi inverse fabric were observed on stereoplots. The characters above, possibly indicate the alteration of the fabric by biogenic activity (reworking) and vertical pedogenic processes. SW and W orientation (influence of Mediterranean) were detected in the fabric of

well-developed soils, however these orientations are possibly not reliable due to the effect of pedogenesis.
High variabilities of the paleoenvironment were described during the early Middle Pleistocene in Central Europe. The wind system was possibly similar to the recent ones, however, some component (e.g. orientation of dominant paleowind direction) became stronger during the glacial or interglacial phase.

Keywords: anisotropy of magnetic susceptibility, Middle Pleistocene, wind direction

East Asian Monsoon variations in marine isotope stage 19 by magnetic and grain size data of Chinese loess deposits

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Marine isotope stage (MIS) 19 is an important target of study, because of its similarity with the Holocene in term to orbital element, and occurrences of the last geomagnetic polarity reversal and cooling event. Loess-paleosol deposits in the Chinese Loess Plateau (CLP) are a good archive of the climate changes of glacial-interglacial cycles and paleomagnetic variations. Thus, loess-paleosol deposits provide a good opportunity to study the climate of MIS 19 and the Matuyama-Brunhes transition (MBT).
We analyzed magnetic susceptibility (MS), frequency dependence (FD) and grain size (GS) of loess-paleosol deposits from two sections in the CLP, to restore detailed monsoon variation in MIS 19. In paleoclimate studies in the CLP, MS is regarded as a proxy of summer monsoon intensity, and GS as that of winter monsoon intensity. The sections are about 7 and 8 m thick, which are from Xifeng in Central CLP and Lingtai about 100 km south of Xifeng, respectively. Specimens were collected at about 2.5 –30 cm intervals. Detailed paleomagnetic analyses, which have been already carried out, reveal the Matuyama-Brunhes transition (MBT) with multiple polarity swings in both sections.
In both sections, MS and FD show similar variations well correlated with the glacial sea-level or ice volume changes indicated by marine oxygen isotope data, having two peaks correlated to highstands MISs19.3 and 19.1, respectively, and a minimum to lowstand MIS19.2. Only the Lingtai section has low MS and FD interval correlated to MIS 20.2. Median GS and the percentage of coarse grains (CG) (Xifeng: φ>16 μm, Lingtai: φ>20 μm) show grains become coarse as MS decreases or summer monsoon intensity weakens at MISs 20.2 and 19.2. These results suggest that both of summer and winter monsoon intensities are essentially controlled by orbital forcing, especially by the precessional component. Therefore, weak winter monsoon is expected to occur during a warm period correlated to highstand. However, coarsening occurs many times in the strong summer monsoon interval correlated to MIS 19.3. In Lingtai, the maximum mean GS almost reaches to that of the glacial period (MIS 20.2). We define the anomalous interval as intensified winter monsoon zone (IWMZ). The uppermost part of the IWMZ is overlapped with the MBT. Many marine core data show the MBT is preceded by a long interval of low paleointensity that starts from around highstand MIS 19.3. The temporary winter monsoon strengthening during the summer monsoon peak may be related to the MB reversal, especially to the low paleointensity.

Keywords: winter monsoon, Matuyama-Brunhes boundary, Chinese Loess Plateau, MIS 19, magnetic susceptibility, grain size

Millennial scale paleoceanographic features during marine isotope stage 19 in Osaka Bay and North Atlantic

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Detailed variations of paleoclimate and paleoceanography are important to clarity the complex environments of Marine Isotope Stage (MIS) 19, a distinct interglacial, that includes a geomagnetic reversal and a cooling event, characterized by a unique orbital situation with minimum of the 400-kyr eccentricity cycle and small amplitude variations in insolation. We examined recently published or obtained high-resolution paleoceanographic data of MIS 19 to extract distinctive common features. Sea-level proxies based on diatom assemblage and grain size data from an Osaka Bay core with an average accumulation rate (a.r.) of 64 cm/kyr show precession-related signals of highstands 19.3 and 19.1, and lowstand 19.2. In addition, they show many sub-orbital scale features at a few kyr intervals, including features spanning for less than 1 kyr. These orbital and suborbital scale features are also observed in high-resolution marine oxygen isotope data from planktonic foraminifera from IODP site U1313, North Atlantic, where an average a.r. 5.4 cm/kyr is estimated. Using the features as tie-points, an age model for U1313 was constructed by transferring the astronomical ages of the Osaka Bay core. The age model shows the Matuyama-Brunhes boundary (MBB) at U1313, the effect of lock-in depth corrected, is dated to be 778 ka, which is 1 kyr older than that for Osaka Bay. High-resolution alkenone-based SST data from U1313 show the warmest interval lying after the MBB, as the warmest climate is observed in Osaka Bay. The age model shows that the warmest SST interval for U1313 ranges in age from about 776 to 772 ka, which is partly overlapped with the warmest climate interval from about 777 to 774 ka for Osaka Bay, both much delayed with the highest sea-level peak at 780 ka. The delayed post-reversal warming in Osaka Bay is interpreted to be caused by the climate cooling associated with the low field intensity during the reversal transition. The millennial scale features common for both sites are also observed in the core data from the Chiba section, a candidate for the GSSP for the early to middle Pleistocene boundary. The features are probably global.

Keywords: MIS 19, sea-level variation, Matuyama-Brunhes boundary, Osaka Bay, North Atlantic

Middle Pleistocene sea-level variations in Osaka Bay well correlated with marine oxygen isotope stratigraphy

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The Osaka Group consists of Plio-Pleistocene sediments continuously deposited in the Osaka Basin. It mainly consists of freshwater deposits in the lower part, and alternating marine and freshwater layers in the upper part. Each marine layer has been designated as Ma-1, Ma0, Ma0.5, Ma1, etc, and correlated with interglacial highstands. However, marine layers Ma6, Ma7, and Ma8 possibly correlated with Marine Isotope Stages (MISs) 15 and 13, have not been studied well and correlations with MISs are obscure because of low amplitude precession-related signals for marine isotope data. Recent studies revealed many marine clay layers defined based on lithology are partly lacustrine. In this study, we examine sea-level changes with diatom and sulfur analysis of Ma6, Ma7, and Ma8 in the Osaka Bay 1700-m core (GS-K1 core) to construct more detailed and precise correlations with eustatic sea-level changes. The aquatic environment and diatom assemblages in Osaka Bay are strongly affected by eustatic sea-level changes through the Kitan Strait, and also by a huge amount of freshwater from the Yodo River. Diatom taxa were grouped into five ecological categories according to salinity tolerance: marine, marine-brackish, brackish, brackish-freshwater, and freshwater. We adopt 3 per mil of sulfur contents to empirical criterion which defines a marine/freshwater boundary. Parts of Ma6 defined in the previous study are lacustrine. The thickness of marine interval is 27.6 m, which is 0.8 m shorter than before. In the lower part of new Ma6, we found a single sea-level highstand correlated with MIS 15.5. The upper part has a zone of no diatoms. However, this zone is marine because it has high sulfur content over 3 per mil. In Ma7, marine interval is newly defined to be 13.9 m thick, which is 5.4 m shorter than the previous one. In the center of new Ma7, we found a single sea-level highstand correlated with MIS 15.1. Between the new Ma6 and Ma7, we found a lacustrine layer of 3.2 m thick that can be correlated with MIS 15.2. We also investigated Ma8, and found Ma8 splits into two marine intervals, probably caused by desalination due to eustatic sea-level fall correlated with MIS 13.2. A tentative astronomical age model shows an average accumulation rate for MIS 15 is 0.86 m/ka, which is much higher than an average for the middle Pleistocene (0.52 m/ka). The high accumulation rate may reflect that tectonic activities including uplifting in mountain areas and subsidence in the basin became high during MIS 15 (621-576 ka) in the Kinki District.

Keywords: sea-level change, Middle Pleistocene, Osaka Group, diatom, Marine Isotope Stage 15, Marine Isotope Stage 13

The Pacific Decadal Oscillation and Japanese history

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The Pacific Decadal Oscillation (PDO) influences climate and the weather in circum-Pacific region. In this study, we discuss changes in Japanese society and famines based on our proxy record of the PDO during the last 2900 years.
A Beppu Bay U^{K}_{37}'-based temperature record indicates that the amplitude of the PDO was larger from 300 BCE to 100 BCE, from 1200 CE to 1500 CE, and from 1700 CE to 1900 CE. The first period corresponds to the late Yayoi period that was characterized by a succession of wars. The second period corresponds to the developing period of medieval feudal society. In the Muromachi period, riots frequently occurred when the PDO was in the positive phase. In the Edo period, major three famines occurred when the PDO was in the positive phase. The positive PDO likely tended to induce a cool-wet or a hot-dry summer in Japan, resulting in lean harvest, destabilizing society.
Diatom records from the Japan Sea and the Okhotsk Sea indicate an intensification of the Tsushima and Soya Warm Currents around 1200 CE (Koizumi et al., 2006; Shimada et al., 2000), which may have been related to the shift of the behavior of the PDO. This timing corresponds to the period of Ainu culture establishment. Changes in fishery resources caused by intensified warm currents may have changed the life style of Hokkaido residence.

Keywords: PDO, paleotemperature, human society

High resolution climate reconstructions in historical times based on the diary weather descriptions and old meteorological records

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The data and methods for scientific research on climatic variations in historical times should be examined carefully in terms of their reliability and methodology for climatic reconstructions. There exist various kind of proxy documentary series of historical data in Japan, among which continuous records of daily weather descriptions in old diaries since 17th century would give us reliable climatic information with high resolution in time and space. Although the quality and quantity of daily weather records are not unified, some diary records include very detailed weather and wind information with several times in a day.
Old meteorological instrumental data, such as those observed in Nagasaki by Dutch medical doctors during 1820s-1850s, and meteorological observations in several cities (Tokyo, Yokohama, Osaka, Mito et al.) by Japanese people, are also valuable and effective for studying long-term climatic variations in Japan. Also, many Light-house meteorological records observed in Japan during 1870s-1880s have been recovered.
Imaging and digitization of old paper-based instrumental meteorological records must be carried out before these records are lost to decay. This kind of activity called “data rescue” is now taking places all over the world. We have recovered instrumental temperature and pressure data for several locations in Japan from the 19th century, a period for which no instrumental records were believed to exist. The recovered data were collected by Dutch, German, French, British, American and Russian visiting Japan and also by Japanese astronomers trained by the Dutch at the time. The data allow extending the beginning of the instrumental record back from 1872 to 1819.The recovered temperature and pressure data were converted to modern units and digitized into computer readable form. The pressure data were corrected for temperature, height, and gravity where needed. The temperature data were homogenized to compensate for changes in recording location. Then, both data sets were homogenized to account for varying observation schedules.
By combining the proxy data (e.g., diary weather records and old meteorological records) with JMA meteorological data properly, it would be possible to reconstruct long-term temperature time-series which is useful for predicting future climate change.

Keywords: climatic reconstrucition, climate variation

Accuracy evaluation of climatic reconstruction with historical daily weather record using old diaries written in the observation period

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Weather records of old diaries are useful source for climate reconstruction in historical times in Japan. Those records have been compiled for since the 11th century for the capital (Kyoto) area, and are widely available for since the 18th century for most part of Japan. Although daily weather records have an advantage of accessibility and high temporal resolution, their description is qualitative and dependent on subjectivity of the author, and therefore evaluation of their accuracy is necessary for reconstructing long-term climatic variation by compiling historical weather records together with modern observed meteorological data. In this study we collected several types of historical daily weather records including private diaries of merchants and scholars and official dairies of temples written in the late 19th to early 20th centuries that parallel meteorological observational records. By comparing weather records with observed data on the daily basis, we found weather descriptions of “light rain”, “rain” and “heavy rain” correspond to a broad range of daily precipitation without distinct boundaries and about one fourth of rainy days are missed in weather record of diaries. Referring to plural diaries and using climatic indices derived by accumulating weather descriptions for months or seasons (such as number of rainy days) is essential to enhance reliability and objectivity of climate reconstruction using such subjective and qualitative information. On the other hand, sharp boundary was found between daily temperatures corresponding to weather descriptions “rain” and “snow”, which implies rain/snow ratio is a promising proxy for winter temperature in the central part of Japan.

Keywords: historical daily weather record, accuracy evaluation, observation period

Present situation and future prospects of the oxygen isotope ratio dendrochronology in the northeastern Japan

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Oxygen isotope ratio ($\delta^{18}O$) dendrochronology has the potential to be conveniently and accurately dating a variety of tree species of old wood material (old building materials, woody remains and natural buried woods). For this reason, $\delta^{18}O$ dendrochronology has been attracting attention as a new dating method in various fields of history, archaeology and geology (Nakatsuka & Sano 2014). Building of tree-ring $\delta^{18}O$ master chronology mainly has progressed in the central and western Japan, reaching already 4300 years ago in some areas (Kimura et al. 2014). On the other hand, it has been delayed in northeastern Japan. Therefore, in this region, the major part of the historical era remained blank data. Because of tree-ring $\delta^{18}O$ is defined in the precipitation and relative humidity of the growing environment, dating is difficult in between the master chronology and old wood material of different rainfall pattern area. Since northeastern Japan is affected by the northeast wind that coming from Okhotsk high in the summer, it is desirable to build independent master chronology (Nakatsuka 2015).
In view of this situation, we has been working on the tree-ring $\delta^{18}O$ analysis of the woody remains and natural buried woods from Aomori Prefecture to Niigata Prefecture. As a result, it succeeded to get in nearly consecutive tree-ring $\delta^{18}O$ data over 1200 years of 5-16 century.
As a result of comparing this data with the existing central Japan $\delta^{18}O$ standard annual ring curve, we found common components on these. Now, we are concidering the reconstruction of the climate field from the spatial pattern of tree-ring $\delta^{18}O$. In this report, we describes an overview of these surveys and analysis, the future prospects.

Keywords: Tree-rings, Oxygen isotope ratio, Climate reconstruction

Stalagmite growth and farming by Jomon Man in mid-Holocene

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Stalagmite study based on U-Th dating in my laboratory has represented new aspects on the Late Pleistocene-Holocene paleo-moisture in Japanese Islands. In turn, results of the U-Th dating imply that growth of many studied stalagmites slowed or stopped in 4000-6000 years ago although dripwater are still active on these stalagmites. This is clearly due to low Ca concentration of the dripwater, and only a few stalagmites are fed by enough Ca concentration for calcite precipitation. Thus, Ca concentration of dripwaters in Japan decreased in mid-Holocene.
Dripwater Ca concentration is primary controlled by pCO_2 at soil/limestone interface where limestone is dissolved. Then, temperature, moisture, and vegetation abundance are main factor for soil CO_2 produced by root respiration and microbial decomposition of organic matter. If the soil CO_2 in the limestone areas decreased in 4000-6000 years ago, at least one of the factors drastically changed at this period.
Considering relatively stable climate during Holocene, the most likely factor was declined vegetation. In addition, inferring from the age of 4000-6000 years ago, a fundamental cause was farming by Jomon Man that had expanded in Honshu in mid-Holocene. It is well known that they preferred to live in limestone areas because they could hide from rain. Their burnt farming may have destroyed thick forest vegetation and resulted in decreasing soil pCO_2 and dripwater Ca, and ultimately in the declined stalagmite growth. We have only little supporting evidence for this hypothesis, but the mid-Holocene peak of fine-grained charcoal in lake deposits implies active farming by Jomon Man. Further examination is required to study detailed charcoal-pollen occurrence in lake deposits, as well to perform radiocarbon dating for burnt wood from the Holocene archeological sites.

Keywords: stalagmite, Holocene, Jomon

Fossil coral-based reconstruction of the Mid-Holocene ocean environment in Okinawa-jima, Japan

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Quaternary paleoclimate records have been extracted from climate proxies such as deep-sea sediments, ice sheets, trees, speleothems, and corals. Continuous long cores from sediments and ice sheets play a leading role in Quaternary paleoclimate reconstructions, although the slow rates of sedimentation frequently preclude them from reconstructions on seasonal and interannual time scales. However, fossil coral archives provide high resolution windows of generally short duration with which to investigate past atmospheric and oceanic conditions at the tropical/subtropical sea surface. Massive *Porites* corals, living in shallow waters of the tropical to subtropical oceans, precipitate annually banded aragonite skeletons. These colonies provide robust chronological control and allow sub-sampling at monthly-to-seasonal resolution. The ages of fossil corals are determined accurately by radiocarbon and uranium-series dating methods. Oxygen isotope composition of coral skeleton reflects variations in sea surface temperature and seawater oxygen isotope composition (salinity) with the latter being closely related to the precipitation-evaporation balance at sea surface and changes in water mass transport. Long-lived corals can be a powerful proxy for documenting paleoceanography at seasonal, interannual, and decadal time scale, but only a few long-records of >50-year have been published from fossil corals. Here we present bimonthly resolved oxygen and carbon isotope composition time series from mid-Holocene corals in coral reef sediment cores drilled at the west coast of Okinawa-jima, the Ryukyu Islands, Japan. Our coral-based climate reconstruction significantly shows seasonal-to-decadal time scale variability of thermal and hydrologic conditions in the northwestern subtropical Pacific during the mid-Holocene.

Keywords: coral skeleton, fossil, oxygen isotope composition, carbon isotope composition, paleo-temperature, the Ryukyu Islands

Heinrich events and last glacial recorded in a stalagmite from Mie Prefecture, Japan

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Stalagmites record physicochemical conditions in isotope and elemental composition in their carbonate fraction. Here, we investigate 10-cm-long stalagmite KA03 collected from Kiriana cave in Mie Prefecture. This stalagmite has high concentration of uranium and provides accurate U-Th ages. Results of dating show that the stalagmite has been growing during the last 80 kyr almost continuously. The oxygen isotopic curve of KA03 generally follows the records from the Chinese caves and Greenland ice-sheets in terms of 1) drastic decrease at the B/A warming, and 2) high isotopic intervals corresponding to the Heinrich events. However, KA03 lacks the millennium changes of Dansgaard-Oeschger cycles, which have been reported in a stalagmite from Gifu Prefecture. A distinct feature of KA03 oxygen isotope is a linear increase from 37 ka to the Last Glacial Maximum (LGM). Assuming that the isotope is a proxy of humidity, the amount of rainfall had been decreasing from 37 ka to LGM. Because the locality is generally dry in winter season, the stalagmite KA03 is a significant record of the East Asian summer monsoon.

Decadal to centennial-scale Asian dust transport changes during the last thousand years recorded in Lake Suigetsu sediment

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Knowledge of decadal to centennial-scale variations in Asian dust transport is critical to understand the interactions between Asian dust and natural environment, and is also important to estimate past atmospheric circulation changes. Here we estimated temporal changes in the content and depositional flux of aeolian dust in sediment core SG12 from Lake Suigetsu, central Japan, during the last thousand years based on the depositional flux (please see Suzuki et al., presented in this session) and grain size of detrital materials.
First we focused on the last century and compared the estimated dust flux changes to the meteorological records. The estimated dust flux shows decadal-scale change with the decrease during 1952–1974, which could be explained by weaker westerlies in lower latitudes including central Japan, reflecting weaker Aleutian Low during the corresponding period.
Similar decadal-scale changes are observed throughout last thousand years, suggesting dominance of similar decadal-scale climate systems in the East Asia and the north Pacific. In addition, the dust record exhibits centennial-scale changes with the decreases during 11–12th, 15th and 18–19th centuries. We will further compare our result with pollen record from Lake Suigetsu and tree-ring records in Asian region, and discuss nature and mechanisms of decadal and centennial-scale climate changes in East Asia.

Keywords: Asian dust, last 1000 years, Lake Suigetsu, decadal-vriation, centennial-variation

Climate and environmental changes during the past 1000 years reconstructed from fluxes of detrital materials of different sources to the Lake Suigetsu sediment

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Fluxes of detrital material in the sediment reflect various climatic factors such as rainfall through river discharge and wind system through transport of eolian dust. Because flux of detrital material is controlled by relatively simple physical process, it has high potential to become a quantitative paleoclimate proxy. If we want to utilize detrital flux as a paleoclimate proxy, we have to separate detrital fluxes from different sources and correlate their records with observational and historical records to specify the physical processes that control the detrital inputs.

In this study, we used Lake Suigetsu sediment core (SG12) drilled in 2012 for chemical and mineralogical analyses to specify different sources of detrital material and estimate their mixing ratio. Because Lake Suigetsu sediment is known to have high-precision and high-resolution age depth model, we can correlate sedimentary record with historical record precisely.

We conducted XRF analysis for major elements' composition and XRD analysis with Rietveld data analysis method to quantify mineralogical composition. Using these data, we conducted factor analysis to extract end members' compositions of the sediment. XRF and XRD measurement is also conducted for detrital materials collected in Hasu River, the major watershed of Lake Suigetsu, and its tributaries to compare with end-members extracted by factor analysis to estimate their sources. In this presentation, we will introduce the chemical + mineralogical data analysis method to reconstruct temporal changes in detrital fluxes from different sources during the past 1000 years.

Keywords: Lake Suigetsu, Factor analysis, Rietveld method

The isotopic measurements of oxygen and hydrogen in Dome-Fuji (Antarctica) ice core: Annually-resolved temperature reconstructions of the past 2000 years

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We present annually-resolved temperature and SST (sea surface temperature) reconstructions of the past 2000 years based on water (oxygen and hydrogen) isotope measurement on a shallow ice core drilled in 2010 at Dome Fuji station, East Antarctica. Those isotopic data are expected to yield information to elucidate the past climatic condition, and they are planed to contribute to integrated efforts for the reconstruction of temperature profile of the past 2000 years, in such as PAGES 2k project.
Dome Fuji station is located on a summit of Dronning Maud Land at an altitude of 3810 m a.s.l. (above sea level) (77° 19' 01" S, 39° 42' 12" E) in East Antarctica. The 10 m depth mean snow temperature at Dome Fuji is -57.3 °C[1)]. The inland area around Dome Fuji has been recognized to be especially unique: The snow and ice there contain much stratospheric information. The direct evidence for this comes from tritium contents originated from the nuclear bomb tests in the 1960s; the tritium fallout at the Dome Fuji site is outstandingly high among 16 snow pit samples widely collected over Antarctica[2)].
To date the concerned Dome Fuji ice core called DFS10, we applied volcanic signature matching to transfer the West Antarctic Ice Sheet (WAIS) Divide ice core chronology constructed by annual layer counting as used in the study by Sigl et al. (2014)[3)]. Based on this chronology of the DFS10 ice core and the measurements of isotopic ratios of oxygen and hydrogen, we have examined the annual changes of $d^{18}O$ to reconstruct the temperature of the past 2000 years. In our presentation, we confine ourselves to discuss the oscillation periodicity that we observed in the oxygen isotope record in our data: The periods of approximately 10, 20, and 200 years were found. We will present the time series analyses for this in detail, and will discuss the origin of this periodicity.
References:
1) Kameda, T., Motoyama, H., Fujita, S., and Takahashi, S.: "Past temporal and spatial variability of surface mass balance at Dome Fuji", East Antarctica, by the stake method from 1995 to 2006, J. Glaciol., 54, 107-116, 2008.
2) Fourre, E., Jean-Baptiste, P., Dapoigny, A., Baumier, D., Petit, J.-R., and Jouzel, J.: "Past and recent tritium levels in Arctic and Antarctic polar caps", Earth Planet. Sc. Lett., 245, 56-64, 2006.
3) Sigl, M., J. McConnell, M. Toohey, M. Curran, S. Das, R. Edwards, E. Isaksson, K. Kawamura, S. Kipfstuhl, K. Kruger, L. Layman, O. Maselli, Y. Motizuki, H. Motoyama, D. Pasteris, M. Severi: "Insights from Antarctica on volcanic forcing during the Common Era", Nature Climate Change, 4, 693-697, 2014.

Keywords: isotope ratios of oxygen and hydrogen, temperature reconstructions of the past 2000 years, Dome-Fuji

Paleoceanographic reconstructions of surface ocean conditions in the East China Sea since the last glacial maximum based on diatoms

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The East China Sea (ECS) has four surface water-masses. The first one is the Chinese coastal water in the north characterized by low salinity, low temperature and high nutrient. The other three water masses are flowed into the ECS from the south: the Kuroshio surface water; the Kuroshio subsurface water; and the Taiwan warm water. The Kuroshio surface water and the Taiwan warm water are characterized by high salinity, high temperature and low nutrient. The Kuroshio subsurface water with high salinity, low temperature and high nutrient penetrates into continental shelf region. During the last glacial period, sea level dropped to -120 m. Therefore, most of the continental shelves of the ECS were aerially exposed and the Yangtze River mouth must have advanced eastward. Diatom assemblages are highly sensitive to environmental changes such as salinity, temperature, nutrient availability. Thus, diatoms have a great potential to reconstruct past environmental changes in surface water of the ECS. However, paleoceanographic studies employing diatom assemblages have been very limited in the ECS. Only Tanimura et al. (2002) suggested that *Paralia sulcata*, a representative near shore species, dominated during the last deglacial termination.

14.1 m-long sediment core was obtained from the Danjo Basin, northern part of ECS (KY0704-PC01, 31°38.35'N, 128°56.64'E, 758 m water depth). Sediment samples for diatom analyses were sub-sampled at every 5 cm and added 30% hydrogen peroxide to degrade organic matter. For light microscope observation, suspended samples were dropped onto coverslip and mounted with Pleurax (Mount Media). For scanning electron microscope (SEM) observation, suspended samples were filtered with membrane filters with a nominal pore size of 0.45 μm and coated by Osmium tetroxide. Diatom taxa were identified under field emission scanning electron microscope (FE-SEM, JEOL JEM-7001F) and light microscope (LM, Olympus BX50 and BX53). 200 diatom valves were counted under LM for each slide.

A total of 45 diatom species were encountered. We classified them into three environmental groups, i.e., near shore, near shore to open ocean, and open ocean. Near shore, near shore to open ocean, and open ocean groups were characterized by *Paralia sulcata*, *Thalassionema nitzschioides*, and *Nitzschia bicapitata*, respectively. Since last glacial period, *Paralia sulcata* and *Thalassionema nitzschioides* have accounted for 25% to 80% in total diatom assemblage. In particular, *Paralia sulcata* was dominated during the last glacial-deglacial periods with low sea-level, suggesting enhanced coastal water input. At 8 ka, *Nitzschia bicapitata* accounted for >20% in total diatom assemblage suggesting warm water flowed into the northern ECS from the subtropical Pacific and the South China Sea flowed into the northern ECS. Based on detailed microscopic observation, we identified that both *Paralia sulcata* and *Thalassionema nitzschioides* in our samples were not a single species but multiple species. These species suggested that repeated intrusion of Chinese coastal water into the Danjo Basin during Holocene.

Keywords: East China Sea, Diatom

Variations in East Asian summer monsoon in the last 400 ky deduced from results of Mg/Ca-sea surface temperature and oxygen isotope of IODP Site U1429

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The East Asian summer monsoon (EASM) system is involved in the hydrological cycle and in latent heat and energy transport, and thus plays a crucial role in the regional and global climate system. Modern summer sea surface salinity in the northern part of the East China Sea (ECS) is mainly controlled by the discharge of the Yangtze River, which reflects East Asian summer monsoon (EASM) precipitation in the drainage area of the Yangtze River. Site U1429 was drilled by Integrated Ocean Drilling Program (IODP) Expedition 346 in the northern part of the ECS to reconstruct the Yangtze River discharge in high temporal resolution (~100 year resolution). A ~200 m long sediment succession was recovered, which covers the last 400 ky based on a benthic foraminiferal oxygen isotope. A record of oxygen isotope of seawater ($\delta^{18}O_w$) was reconstructed, based on high-resolution Mg/Ca and oxygen isotope measurements of the planktic foraminifera *Globigerinoides ruber.* The $\delta^{18}O_w$ shows variations that have been in concert with Chinese spleothem oxygen isotope records on millennial to orbital scales. However, comparison with a global mean $\delta^{18}O_w$ reveals that the $\delta^{18}O_w$ of U1429 follows the global mean except from MIS 7.3 to MIS 6.4 and from MIS 5.4 to MIS 4, when the $\delta^{18}O_w$ of U1429 was higher than the global mean during MIS 7.2, 6.4, 5.4, 5.2, 4 and lower during MIS 7.3, 7.1, 6.5, 5.3, 5.1. These intervals correspond to higher eccentricity periods during the last 400 ky. During these time periods, the amplitude variations of the regional $\delta^{18}O_w$ increased, suggesting that the 23 ky amplitude of the EASM precipitation was also enhanced. These results suggest that the 23 ky amplitude of the EASM precipitation has been modulated by the eccentricity.

Keywords: Monsoon, East China Sea, Milankovitch cycle, Mg/Ca-temperature, Oxygen isotope

Mid to Late Pleistocene paleoceanographic history of the northern East China Sea based on radiolarian data (IODP Exp. 346 Site U1429)

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The East China Sea (ECS), is a marginal sea, influenced by the East Asian Monsoon (EAM) and Kuroshio Current (KC). The hydrography of the northern part of this area is highly influenced by discharges of fresh water from the Yangtze River during summer lead by the East Asian summer monsoon. In summer-autumn 2013, the IODP Expedition 346 could retrieve sediments cores in the northern ECS from Site U1428 and U1429 in order to reonstruct the regional paleoceanographic history of this area, focusing on the interaction between East Asian Summer Monsoon, Yangtze River discharges and Kuroshio Current. On the other hand, radiolarians are micro-organism group bearing siliceous skeletons, widely distributed in the world ocean, living from shallow to deep water masses. In the ECS, few studies increase our knowledge's concerning radiolarian ecology and its relationship with temperatures changes. Therefore, we have investigated changes in radiolarian assemblages down core Site U1429 since the Mid- Pleistocene for clarify the fluctuation pattern in KC water and Yangtze River discharges through the Pleistocene glacial/interglacial climatic changes. We have also reconstructed past Summer Sea Surface Temperature based on shallow water radiolarians in order to discuss the possible interaction and impact of the EAM, Yangtze River discharges and KC on the regional hydrography
As a summarizing result, we identified that radiolarians related to Kuroshio Current waters, such as *T. octacantha* group and *D. tetrathalamus* were abundant at the MIS 1, MIS 5e and MIS 7, which caused a warming of the regional shallow water (>26 ℃). During de-glacials, the abundances of radiolarians related to the Yangtze River discharges (e.g. *P. obeliscus* and *C. calvata*), drastically increased. During glacials, *L. setosa*, a species related to temperate coastal water dominated the assemblages involving a cooling of the shallow waters (between 21 and 22℃). Several changes could be also identified for the intermediate water during the studied time interval. We recorded high abundances in taxa related to subarctic water during glacials (MIS 2 and 6), while, intermediate water dwellers specific to the ECS show their higher abundances during interglacial (MIS 1, 5), excepting the MIS 6 and 7.

Keywords: East China Sea, Paleoceanography, Radiolarians

Paleoenvironmental change associated with sea level drop during Marine Isotope Stage 3 in the Bonaparte Gulf

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During the Marine Isotope Stage 3 (MIS 3), ice volume changed in the short period and increased to the maximum volume in the Last Glacial Maximum (LGM). Accurate relative sea level records at far-field site, remote form ice-covered area, provide the ice volume information. However, the MIS 3 sea level records at far-field site are limited by the availability of dataset. The Bonaparte Gulf, northwestern Australia, is tectonically stable region and located at the far field. This Gulf has the carbonate platforms, which were exposed during the sea level lowstand. We show the paleoenvironmental change associated with sea level drop during MIS 3 using the marine sediments core from the Bonaparte Gulf. The primary information for the timing of exposure is calcium variation standardized by titanium. Total organic carbon, C/N ratios, and ^{14}C age offset (offset between the carbonate and organic matter age) also provide the paleoenvironmental information on the exposure of carbonate platform. We concluded that sea level drop occurred at ca. 26 ka, which is consistent with previous works as Huon Peninsula records. This drop is associated with Heinrich event 2.

Keywords: Sea Level, Paleoenvironmental change, Radiocarbon dating

Iceberg discharge from the Laurentide ice sheet to the western Arctic Ocean during the last glacial period

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The last glacial was characterized by millennial-scale abrupt climate changes, such as the Dansgaard-Oeschger (DO) cycles. The Heinrich events (HE) are a potential trigger of the abrupt warming from stadial to interstadial states, but the DO cycles were not always associated with the HE. The rate of cooling from interstadial to stadial states were variable, and its factor controlling the rates remains an open question. To answer these questions, the reconstruction of icebergs discharges in the western Arctic Ocean is necessary.

In this study, we established the stratigraphy of the Chukchi Borderland sediments during last 76,000 years and assigned the provenances and transport processes of sediments. We tried to discuss the iceberg discharges from the Laurentide ice sheet and their influences on the warming and cooling of glacial millennial climate changes. For this purpose, we used five sediment cores retrieved from the western Arctic Ocean by during 2011 and 2012 RV “Araon” cruises. We analyzed ice-rafted debris (IRD) content, mineral composition, grain size distribution, color, organic carbon, total nitrogen and total sulfur contents, stable carbon isotopes of organic matter, and glycerol dialkyl glycerol tetraethers (GDGT) compositions in those sediments.

Dolomite-rich layers were recognized at 9 ka, 11 ka, 42-35 ka, 45 ka, and 76 ka. Sedimentological properties suggest that they were derived from the Canadian Arctic Archipelago by iceberg rafting. Their deposition occurred when the sea level was 40-80 m lower than today. We suppose that the northern margin of the Laurentide ice sheet reached to the Arctic Ocean, and the calving of icebergs was not prevented by thick ice shelf nor sea ice during the periods. The deposition of dolomite-rich layers at 9 ka and 45 ka corresponded to H0 and H5 events, respectively. At both timings, interstadials continued longer than other interstadials. We speculate that the large collapse of the Laurentide ice sheet delayed ice-sheet build-up and a resultant cooling. Evidence of no iceberg discharge into the western Arctic during 53-11 ka indicates that the warming of interstadials 1 to 4 was not related to the collapse of the Arctic sector of the Laurentide ice sheet. A kaolinite-rich layer was found during the last deglaciation, which enables us to speculate that the deposition was related to the collapse of ice dam and an event of freshwater discharge.

Temporal flux change in diatom assemblages in seasonal sea-ice covered region off Sakhalin Island in the Okhotsk Sea

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"Ice" is a subsystem of the Earth's climate system and reconstruction of past ice-sheet and sea-ice dynamics is one of the important topics for paleoenvironmental sciences. Sea-ice floating on the sea-surface plays a key role in constraining sea-surface temperature because of its high albedo and insulation effect between atmosphere and ocean. Ice algae in sea-ice and ice-rafted debris (IRD) are representative proxy for past sea-ice coverage. Diatom frustules are made of biogenic opal which can be well-preserved in sediments as a micro fossil. Therefore, to understand a relationship between modern diatom assemblage and sea-ice coverage helps to reconstruct past sea-ice distribution.

Time-series sediment trap was moored at Station M4 off Sakhalin in the Okhotsk Sea from September, 1999 to June, 2000. Based on satellite observation, sea-ice covered at Station M4 December 1999 to April 2000. Nakatsuka et al. (2004) reported biogenic opal flux at Station M4, showing the low fluxes when sea-ice was covered.

In this study, We investigated diatom assemblages in 21 sinking particle samples at Station M4 from September, 1999 to June, 2000 by using light microscope (LM) and field emission scanning electron microscope (FE-SEM). A total of 36 diatom species including sea-ice and sea-ice related species were encountered during the microscopic observation. Diatom fluxes at Station M4 were significantly low when sea-ice covered. The diatom flux in November (sea-ice free) was greater than 30 times as that in April (sea-ice maximum). Diatom assemblage at Station M4 also changed with sea-ice coverage. During sea-ice free period, *Shionodiscus* and *Proboscia* species were abundant. Sea-ice related species started to increase with sea-ice coverage. Resting spore of *Bacterosira bathyomphala* was a major diatom taxa during sea-ice development. During sea-ice maximum, *Fragilariopsis cylindrus* flux showed pronounced peak. We found that flux peaks of each sea-ice related species. This suggests that diatom assemblages have a potential to reconstruct not only for presence of past sea-ice but also for magnitude of past sea-ice.

Reference:T. Nakatsuka, T. Fujmune, C. Yoshikawa, S. Noriki, K. Kawamura, Y. Fukamachi, G. Mizuta, and M. Wakatsuchi (2004). Biogenic and lithogenic particle fluxes in the western region of the Sea of Okhotsk: Implications for lateral material transport and biological productivity. Journal of Geophysical Research 109, C09S13, doi:10.1029/2003JC001908

Keywords: Okhotsk Sea, Diatom, Flux, Sea-ice

Elemental carbon contents in the Bering Sea sediments during glacial-interglacial cycles

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Elemental carbon (EC) is produced by incomplete combustion of organic matter. EC can be well-preserved in sediments because of the low volatility and chemically inert compared with organic carbon (OC). Although EC has a potential to be a proxy for paleo-fire, our knowledge on EC change during glacial–interglacial cycle is limited. In this study, we measured EC contents in the Bering Sea sediments for the last 500 kyrs during the glacial-interglacial cycles. In summer 2009 during Integrated Ocean Drilling Program (IODP) Expedition 323, sediment core was drilled at Site U1343 on a bathymetric high near the Bering slope (57°33′N, 175°49′W, water depth: 1950 m). Age model of U1343 cores was established based on oxygen isotope stratigraphy of benthic foraminifera as well as bio- and magneto-stratigraphies. The established age model enables us to identify each glacial and interglacial periods based on Marine Isotope Stage (MIS). Selected sediment samples from typical glacial (MIS 2 and 12) and interglacial (MIS 1, 5, 9, and 11) were used for EC analysis. EC contents were measured by thermal separation method using Semi-Continuous OC-EC Field Analyzer (Sunset Laboratory Inc.). Thermal separation method is one of the carbon component analyses, which distinguish between EC and OC based on volatility. Volatilization temperature of EC is higher than that of OC. Before measurements, carbonate was removed by 20% acetic acid. EC contents at Site U1343 were high in glacial and low in interglacial periods. During glacial periods, vast continental shelves in the Bering Sea near Site U1343 were aerially exposed (Beringia) due to sea-level drop. We suggest that high EC contents during glacial periods were likely due to an increase in transportation of sediment from the Beringia.

Keywords: Elemental carbon, Bering Sea

Biomass burning history deduced from elemental carbon variability at IODP Exp. 346 Site U1423 during the last 4 million years

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The burning of trees and grasses produces charred particles such as charcoal and soot that may be transported long distances via winds and rivers to coastal, deltaic, and ocean environments where they may become preserved in the sediments. Charcoal contained in sediments has been widely used as a proxy for biomass burning and human activities as well as climate change. Charcoal and soot in Cenozoic marine sediments at IODP Exp. 346 Site U1423 was measured to examine the regional history of biomass burning in the East Asia and carbon sequestration in the ocean.
IODP Exp.346 Site U1423 is located in the northeastern Japan Sea and the water depth is 1785 m. Relatively low Linear sedimentation rates (LSRs) are anticipated based on results from the site survey. The LSR are likely to be low enough to detect the contribution of minor amount of charcoal or soot from the surrounding land. One hundred nine samples have been collected from interval between 0 and 200 m CCSF-D which cover the last 4.3 m.y. Charcoal and soot were measured as elemental carbon (EC) in coarse (>2 um) and fine (<2 um) fractions, respectively, using thermal optical transmittance (TOT) method followed by grain size separation using repeated settling. Organic carbon (OC) was also quantified during the process.
EC and OC in both coarse and fine fractions are higher from 0 to 1.8 Ma and lower from 1.8 to 4.3 Ma with large variation, which suggests more frequent or intense biomass burning since 1.8 Ma. The fact that dark layer samples contain higher OC and EC also suggests net carbon input or preservation controls the amount of OC and EC in the sediments. Comparison of OC and EC variabilities with vegetation change reconstructed from pollen analysis suggests that OC and EC was high both in coarse and fine fractions in warm and wet environment. Terrestrial biomass and precipitation could be major control on EC supply. Fine EC varies independently from coarse EC, which suggests remote origin of fine EC. High temperature resistive EC is associated with grass dominant vegetation, while coarse EC is lower (fine EC is higher) when wood vegetation is dominant suggesting that vegetation type could affect the type of burning products.

Keywords: biomass burning, elemental carbon, IODP Expedition 346 Site U1423

Coupling of climate, dust and productibity in the Southern Ocean during the late Miocene to Pleistocene

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Dust potentially affects global climate via the direct and indirect effect on radiative balance of the atmosphere and by supplying essential limiting micronutrients such as iron to the ocean. In fact, supply of dust to the Southern Ocean increases during the glacial periods of the late Pleistocene may have contributed to the decrease in concentration of CO_2, suggesting strong coupling of climate, dust and productivity in the subantarctic Southern Ocean during the Pleistocene. However, link among the climate, dust and productibity in earlier times and its role in the evolution of the long-term climate since the late Miocene have remained unclear. Here we report long-term record of SST, dust and productivity in the Southern Ocean over the past 10 million years based on the analysis of marine sediments from ODP Site 1123, South Pacific sector of the subantarctic zone. Our new records show strong coupling of climate, dust and productivity over the past 10 million years with increase in dust and productivity during cold glacial periods including the late Miocene cooling (6-7 Ma). This finding suggests that the Southern Ocean played a key role in drawdown of atmospheric CO_2 level during the late Miocene.

Keywords: Climate change, SST, Late Cenozoic, dust, productivity, Southern Ocean

“Diatomaceous ocean weathering”: a new concept to understand the paleoceanic environment

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“Diatomaceous ocean weathering” is a novel physiological action of diatoms, where diatoms disintegrate silicate minerals and incorporate metals in the minerals into their frustules.

The action was inferred in discussing the rare earth element (REE) composition of siliceous matter in diatom-rich settling particles in the Bering Sea. Since then, we have foraged pieces of evidence for the radical action of diatoms. The evidence includes: 1) a fully-consistent picture of the oceanic REE cycling, 2) a balance in REE budget in a water column identified using Nd isotope ratios, 3) evenly-distributed SEM images of Al in diatom frustules, 4) presence of authigenic Al, which is spectroscopically different from that in clay minerals, and 5) numerous earlier analytical studies reporting failure to separate elements in clay and those in diatom frustules.

In this paper, how the new knowledge on the diatomaceous action will affect the interpretation of the distribution of Nd isotope ratios. An example to apply the action to Nd isotope variation recorded in ferromanganese crusts will be presented. It will be shown that quite distinct, but surprisingly reasonable changes in the paleoceanic environment (pCO_2 and Si concentration) will be emerged from the discussion.

Keywords: diatoms, weathering, Nd isotope ratio

Biogeochemical cycles and conditions for photic zone euxinia in the ocean

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Ocean anoxic events (OAEs) have occurred repeatedly during the Phanerozoic. Sedimentological studies have revealed that there was sometimes hydrogen sulfide in the water column, which is called ocean euxinia. Organic geochemical studies of black shales deposited at some of OAEs have revealed the presence of a specific molecule (biomarker) isorenieratane which is derived from green sulfur bacteria. Because these obligatory anaerobic photoautotrophic bacteria require both the light and hydrogen sulfide, it is indicated that there was hydrogen sulfide in photic zone (an uppermost 100~200 m of the surface ocean) at that time. This is remarkable because the photic zone is usually oxic owing to mixing with the overlying atmosphere which contains molecular oxygen as much as that of today throughout the most of the Phanerozoic. The condition and mechanism to cause such a photic zone euxinia (PZE) have been largely unknown. In order to understand PZE, we model the physical-chemical water column structure and the biogeochemical processes for the surface ocean. A new one-dimensional marine ecosystem-biogeochemical model, which has a high vertical resolution of ~5 m, was developed, and a series of parameter studies were performed. We found that the depth of chemocline (= the depth of dissolved oxygen/hydrogen sulfide boundary) resides at around 150 m which is determined by the limit of photosynthesis of algae due to light and also by the use of hydrogen sulfide due to green sulfur bacteria. We also found that the PZE is caused when the concentration of phosphate in seawater is higher than 8 mM which corresponds to the riverine flux of ~2.5 times the present value for the pelagic zone, while at the coastal upwelling regions PZE would be achieved when phosphate is higher than 5 mM which corresponds to the riverine flux of 2.1 times the present value. The riverine phosphate is derived from continents through chemical weathering, hence these two estimates correspond to the climatic conditions of 6 K and 11 K warmer than it is today, respectively. This result is consistent with the case of OAE2 (in the mid-Cretaceous, about 95 Ma) which occurred at the period of climate warming

Keywords: photic zone euxinia, ocean anoxic event, biogeochemical cycle

Changes in the Oligocene planktic foraminiferal depth habitat related to thermocline deepening in the eastern equatorial Pacific

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Planktic foraminiferal depth habitat is a key to accurate reconstruction of paleoceanographic records. Oligocene-Pliocene long-ranging species *Dentoglobigerina venezuelana* lived in the mixed-layer (shallower) in the eastern equatorial Pacific during the early Oligocene while the same species calcified within thermocline depth (deeper) during the late Oligocene and Miocene. The exact timing of its depth habitat change and possible relationships with Oligocene climate dynamics are still unknown.

Here we reveal successive isotopic record of *D. venezuelana* along with *Paragloborotalia siakensis* group (mixed-layer dweller) by using sediments at IODP Site U1334 in the eastern equatorial Pacific throughout the Oligocene. Two-step depth habitat changes of *D. venezuelana* are recognized: 1) from upper to lower mixed-layer (~27.4 Ma), and 2) lower mixed-layer to thermocline depth (~26.3 Ma). In addition, planktic foraminiferal faunal assemblage also experienced significant change from dominant thermocline (deeper) species to abundant mixed-layer (shallower) species, suggesting depth habitat shifts of *D. venezuelana* was closely related with thermocline deepening in the eastern equatorial Pacific.

Multiple sites (Sites U1334, U1333, and 1218) comparison of first isotopic shift (~27.4 Ma) revealed southward depth habitat change of *D. venezuelana* within ~200 kyr, implying thermocline deepening occurred with reduced steepness in the eastern equatorial Pacific. Consequently, we advocate global warming condition during the late Oligocene likely caused thermocline deepening with upwelling decrease in the eastern equatorial Pacific, guiding *D. venezuelana* to adapt deeper depth in the water column.

Keywords: eastern equatorial Pacific, Oligocene, depth habitat, planktic foraminifera, oxygen-carbon isotope ratio

Deep-sea Circulation Turnover Recognized in the Transition Period from the Warm Period to the Cool Period in the Cretaceous

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Globally warm climates from the Albian to the Coniacian were followed by cool climates from the Campanian to the Maastrichtian. Although deep-sea circulation is related to global climate, this relationship remains unclarified in the Cretaceous. This paper reconstructed deep-sea circulation during the middle to late Cretaceous using carbon and oxygen isotopes from benthic foraminiferal tests at 1,000-2,000 m paleowater depth in the Pacific, Indian, North Atlantic, South Atlantic, and Southern Oceans. The carbon isotope data showed that the water masses in the Pacific and Indian Oceans were newer than those in the North Atlantic during the early Cenomanian and Coniacian, but the reverse occured during the OAE 2, the mid-Campanian, and the Maastrichtian. Deep-sea temperature determinations based on the oxygen isotope data showed that the reverse of the global deep-sea circulation characterized the transition from the warm to the cool period. Based on the current understanding of the relationship between deep-sea circulation and temperature during the Paleocene-Eocene Thermal Maximum, the sources of the warm-water circulation culminated at the OAE 2 wheras the cool-water circulation derived from the middle-low latitudes and high latitudes.

Keywords: Cretaceous, Deep-sea circulation, benthic foraminifera, carbon isotope, oxygen isotope

Linkage between LIPs formation and environmental changes in Pacific during the Cretaceous OAE 2.

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Mid Cretaceous period (120-90 Ma) is characterized by the greatest value in the rate of ocean crust production over the past 150 million years. During this period, a lot of Large Igneous Provinces (LIPs) were emplaced in the Pacific, Atlantic and Indian oceans. Since the emplacement ages of the Cretaceous LIPs are concurrent with the Oceanic Anoxic Events (OAEs), various hypotheses explaining the linkage between the LIPs and OAEs have been proposed since the end of 1980's. A popular hypothesis attributes the high productivity and thereby ocean anoxia to the increased supply of biolimiting metals into photic zone during the LIPs formation (e.g., Snow et al., 2005). Another hypothesis explains the reason of increased productivity that elevated sea level as well as pCO_2 by LIPs eruption caused increase in global warming and continental runoff, which delivered terrestrial nutrient to ocean surface (e.g., Monteiro et al., 2012).
In order to understand linkage between large volcanic eruption and environmental change during OAE 2 (94 Ma), we examined the OAE 2 intervals of the Great Valley Group and the Yezo Group exposed in California, USA and Hokkaido Japan, respectively. The former sequence was deposited in the continental slope of eastern Pacific while the latter was in the continental slope of western Pacific. The samples were analyzed for total organic carbon content (TOC), degree of pyritilization (DOP) and assemblage of benthic foraminifera. The analytical results were correlated with the Os isotope stratigraphy and U-Pb zircon ages of tuffs obtained from the same samples by Du Vivier et al. (2015). Os isotope of the studied sequences exhibit abrupt decrease 35,000 year before the onset of the OAE 2 and gradual increase 200,000 years after the onset of the OAE 2 (Du Vivier et al., 2015). Based on the results of benthic foraminifera, TOC and DOP analyses, most of the studied sequences exhibit oxic environment in both sections. However, two short term dysoxic intervals were identified. One is the interval from the onset of the OAE 2 to 50,000 year after onset of the OAE 2, and another is that from 200,000 to the 300,000 after the onset of the OAE 2. The two dysoxic intervals are identical between the western and eastern Pacific, and accord well with the horizons of increase in Os isotope ratio. These evidences suggest that increased runoff caused the depletion of dissolved oxygen in the ocean at least in the eastern and western Pacific continental margins during the OAE 2.
References
Du Vivier, A. D. C., Selby, D., Condon, D.J., Takashima, R., Nishi, H., 2015. Pacific $^{187}Os/^{188}Os$ isotope chemistry and U–Pb geochronology: Synchroneity of global Os isotope change across OAE 2. Earth Planetary Science Letters, 428, p. 204-216.
Monteiro, F. M., Pancost, R. D., Ridgwell, A., Donnadieu, Y., 2012. Nutrients as the dominant control on the spread of anoxia and euxinia across the Cenomanian-Turonian oceanic anoxic event (OAE2): Model-data comparison. Paleoceanography, 27, PA4209, doi:10.1029/2012PA002351.
Snow, L. J., Duncan, R. A., Bralower, T. J. (2005) Trace element abundances in the Rock Canyon Anticline, Pueblo, Colorado, marine sedimentary section and their relationship to Caribbean plateau construction and oxygen anoxic event 2. Paleoceanography, 20, PA3005, doi:10.1029/2004PA001093.

Keywords: Cretaceous, LIPS, OAE

Decadal- to orbital-scale paleoclimatic changes in the mid-Cretaceous “supergreenhouse” evidenced from Mongolian lacustrine records

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Understanding the global climate system during extremely warm “supergreenhouse” periods, such as the mid-Cretaceous, is one of the major aims of paleoclimatology. Hasegawa et al. (2012) suggested the drastic shrinkage of the Hadley circulation and enhanced mid-latitude hydrological cycle with wavier westerly jet stream during the mid-Cretaceous, based on the spatio-temporal reconstruction of desert distribution and paleo-wind pattern. However, the mechanism of such a drastic change in atmospheric circulation system have been poorly constrained, due to the lack of appropriate datasets. Here we present results of our ongoing research project targeting on annual- to orbital-scale paleoclimatic reconstruction based on a mid-Cretaceous lacustrine record in Mongolia.
The Aptian lacustrine deposits (Shinekhudag Formation) are widely distributed in southeastern Mongolia. In the type locality Shine Khudag area, the formation is about 250 m thick and composed alternating beds of dark gray shale, light gray dolomitic marl and yellowish dolomite. The shale and dolomite successions are rhythmically alternated (decimeter-, meter-, tens of meter-scale), which are thought to be formed primarily by lake level changes reflecting precipitation changes. Dark gray shale bed is well-laminated, consisting of micrometer-scale couplets of algal organic matter and detrital minerals. To obtain the continuous paleoclimatic record of this unique lacustrine deposit, we have drilled two scientific research cores (CSH01, 02) in Shine Khudag area in 2013 and 2014 summer.
Based on the radiometric age dating and detail chronostratigraphic study, the Shinekhudag Formation is considered to be deposited between ca. 123–119 Ma, and the calculated sedimentation rate is ca. 6.3–12.5 cm/kyr (Hasegawa et al., in revision). Given the average thickness of micro-lamination and calculated sedimentation rate, micrometer-scale laminations (couplets of organic matter and detrital minerals) in shale and dolomitic marl beds are most likely varves, reflecting seasonal cyclicity. Lacustrine varve record is a powerful tool to reconstruct detail climatic and chronological record (e.g., Wolff et al., 2011; Nakagawa et al., 2012). Thus, the Shinekhudag Formation have a potential to record the annual-scale climatic change and seasonal changes in mid-latitude Asia during the Aptian time.
In order to obtain the paleoclimatic signals and their controlling factors from the Shinekhudag lacustrine record, we performed XRF and ICP-MS analysis for major and minor element compositions of the bulk samples. Based on the factor analysis of major and minor element compositions, several climatic signals (e.g., precipitation, redox condition of lake bottom) were obtained. Spectral analysis of each factor scores reveals that cycles involving approximately 2, 6, 20, 40, and 100 kyr, based on the average sedimentation rate of 10 cm/kyr. The later values are in accordance with orbital precession, obliquity, and eccentricity cycles, respectively. Therefore, Shinekhudag

lacustrine deposits are interpreted to record the millennial- to orbital-scale paleoclimatic changes during the mid-Cretaceous “supergreenhouse” period.
Furthermore, although precipitation proxy (e.g., Si/Al, Ca/Al) shows a strong precession and eccentricity cycles, proxy for redox condition of lake bottom (e.g., P/Al, U/Al, Mo/Al) shows a clear obliquity cycles, suggesting different responses to the orbital insolation. Both the sediment mineralogy and palynofacies assemblages correspond also to the precession and eccentricity-paced precipitation (lake level) changes, except for the calcite contents and algal cysts abundance. Lake surface productivity signal is thought to be more sensitive to orbital insolation forcing. Thus, to verify the variation and cyclicity of lake surface productivity signal and its relationship to other climatic signals, elemental analysis (TOC, TN, TS) are now conducting.

Keywords: lake, greenhouse, varve, precipitation, productivity, orbital forcing

Highly precise depth control method for precise correlation of paleoclimate records

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Considering the spatio-temporal variation of paleoclimate, it is important to establish precise age depth model independent from proxy data and correlate each data and location precisely. In terms of the age, absolute / relative dating methods are used and developed to minimize the error of age estimation and correlation.
On the other hand, it is necessary to estimate the error of the depth itself to connect paleoclimate data (paleoclimate vs. depth) and age data (age vs. depth) precisely.
In the case of sediment core, there are cases when the part of the core is lacked or the shape is changed in a scale of ~cm caused by drilling, splitting and time course. The depth errors caused by these events correspond to 10 - 10000 years in the age scale. This error cannot be ignored relative to reduced error of age estimation methods. Therefore, precise depth control and evaluation of these errors are important to constrain the age error of paleoclimate data.
In the KR15-10 cruise carried near Wakasa-Bay, we corrected piston core samples in multiple locations with different depth to establish the correlation network between sediment cores taken from Japan Sea and Lake Suigetsu. In this cruise, depth control method established in Lake Suigetsu drilling projects (SG06/12/14) is applied to reduce the error of the depth.
Based on high resolution photographs of half split cores and description of the position of marker layers in each processes of the sediment core, correlation, mutual complement and depth conversion is conducted between multiple sites, holes, half-split cores and sub-samples on software. As a result, a composite depth scale is established which is compatible to each core and its data in 1mm precision which corresponds to 10 years in the sediment of Japan Sea.
This depth control method is also applied to micro tephra sampling and analysis which enables us to correlate multiple locations and other core sites.
In this presentation, we would provide the method of depth control applied in KR15-10 cruise and future prospects.

Keywords: Japan Sea, Lake Suigetsu, Age depth model

Variability of elemental carbon input to the Lake Suigetsu sediments during the last 15,000 years

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Biomass burning in geologic ages has been controlled by natural variabilities in environment such as atmospheric oxygen concentration, vegetation, and climate, while human activity may have become another major controlling factor on biomass burning since Holocene. Measurement of elemental carbon (EC) in sediment archive is widely used to reconstruct biomass burning in the past. In order to evaluate drainage-scale influence of human activity and vegetation on biomass burning, we examined the EC in SG12 sediment core collected from the Lake Suigetsu, for which high resolution stratigraphy and age model has been already established and long-term human activities since 12,000 years ago is known from the remains of Jomon. EC is also classified into soot of submicron size and coarse grained charcoal, and the former can be transported for a long distance in the atmosphere. We also tried to evaluate the soot size EC independently from the charcoal size EC by grain size separation of the sediment samples in order to distinguish charcoal input from drainage from atmospheric soot input. Thermal optical transmittance (TOT) method was used to quantify and examine the EC fraction in fine (<2 um) and coarse (>2 um) fraction of the sediment.

High temperature resistant EC is dominant in coarse fraction which resembles to the EC fraction in surface water of the Lake Suigetsu and river waters flowing into the Lake. On the other hand, fine fraction of sediment contains less high temperature resistant EC which is similar to airborne materials collected at the Rishiri Island during Siberian fire in 2014. These facts suggest that coarse and fine EC are originated from drainage and airborne materials, respectively.

Temporal variability of coarse EC flux reconstructed from SG12 core shows increase at ~6500 years ago and ~2500 years ago, but does not show rapid increase from 6500 to 4000 years ago observed in charcoal contents measured from soils in Jomon remains. Vegetation change at 6500 years ago could be more responsible for the increase in the coarse EC. The increase at 2500 years ago could correspond to the onset of Yayoi culture around the Wakasa area. Fine EC flux variation is characterized by the gradual decrease after 9500 years ago and rapid increase at 2500 years ago. This pattern is similar to the Holocene charcoal variability compiled from the data in the Asia monsoon region, which suggests that fine EC could reflect regional-scale biomass burning history.

Keywords: elemental carbon, Lake Suigetsu, Holocene

Transfer function from sand content to paleo water depth of Lake Biwa

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One hundred and twenty bottom surface sediments have been obtained along the coastal area of Northern Lake Biwa from the river mouth of Echi to off Hikone city. Each sand contents were analyzed by sieving. We made a transfer function of sand contents to paleo water depth based on sand content at each station and its sampling water depth.
In general, sand contents are more than 90% in areas shallower than 5m and less than 50% in areas deeper than 10m, that is, sediments change from sandy to muddy at areas deeper than 10m. In addition, sand contents become less than10% at areas deeper than 18m. However, areas off river mouth of Echi and Yanagawa town, sediment show relatively higher sand content than other areas. Based on these data of sand contents and water depth, we found third order approximation and made it as a transfer function. Based on this transfer function and sand content data of drilled core obtained at northeastern part off river mouth of Echi, we plan to clarify paleo water level change history of Lake Biwa.

Keywords: Lake Biwa, Lake level change , sand content

Lake-level change history based on sand content of drilled core during the last 60ka in Lake Biwa

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We here discuss the lake-level change history of Lake Biwa based on sand content of drilled core taken off the river's mouth of Echi. Drilled station located off north east of river's mouth of Echi, water depth is about 23.45m and the length of this sample is 20.5m. Subsamples were cut as 1cm in length and the sand content was measured by sieving method excluding contaminated sediments. Based on the age of widely spreading tephras and 14C ages of plant fragments we made an Age-model of the sediment. Lake-level change was estimated by the transfer function of sand content to water depth by Terada et al. Comparison of Total Organic Carbon (TOC) content profile at the central part of the lake and the sand content profile show that the lake-level was higher in cold stages before 15ka, and that higher in warmer stages after 15ka. The cause of this correspondence is still in open question. Zonal shift of the prevailing westerlies caused by global climatic changes might be one of the facters.

Keywords: Lake Biwa, Lake level change, Sand content, Sediment, Climate change

Depth variation of diatom assemblages in surface sediments off estuary of Echi River , Lake Biwa

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We investigated the diatom assemblages in surface sediment samples from the lake bottom from 5m depth to 30m depth off estuary of Echi River, Lake Biwa.The number of valves and frequency in surface diatom assemblages indicates that they are characterized by depth variation. In particular, the number of valves is characterized by remarkable increasing between 20m depth and 25m depth. And frequency of each species is characterized by remarkable decreasing of benthic and attached diatoms between 5m depth and 20m depth.Sand contents in the same samples indicates that depth variation of diatom assemblage may relate to sand contents of surface sediments.We expect that more detailed investigation of the relationship between diatom assemblage and lake depth will contribute to the reconstruction of freshwater paleoenvironments.

Keywords: Lake biwa, Off estuary of Echi River, Diatom assemblages, Water depth, Surface sediments, sand contents

The formation process of the precipitation type lamina and the estimation of paleo-precipitation in the coastal lagoon

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In the coastal area of the Sea of Okhotsk in the east part of Hokkaido located to for subarctic zone, many brackish-water lakes are distributed. Lake Mokoto has two-layer structure of polyhaline surface waters and mixoeuhaline bottom water. The bottom water shows the anoxic conditions in summer season. In this reason, the sediments of Lake Mokoto consist of organic mud with the lamination. The 09Mk-1C and 09Mk-2C cores collected from Lake Mokoto at 2009. In the soft X-ray photograph, the cyclic lamina set is observed in their core. It is considered that this cyclic lamina set is the varve depending on summer precipitation from result of core analysis. In 2015, we were able to take the new core (15Mk-3C core). We have observed a new lamina set in detail from 2009 to 2015, and compared with precipitation pattern in Abashiri Region. And we are discussed about the possibility of paleo-precipitation analysis from the past of the lamina pattern.

As a result of comparison with 15Mk-3C and 09Mk-1C cores using by the soft X-ray photograph, it is possible to correlate with the two cores in lamina level except for some horizons. Because of correlation lines are substantially parallel, the two cores are seems to shows the same sedimentation rates. From the correlation of two cores, new sediments show the 13cm during about 6 years (sedimentation rate: 2.2 cm/y).

New sediments are subsampled in ca.1.25 mm interval, and were carried out CNS elemental analysis. In low density lamina, Total organic carbon (TOC) , total nitrogen (TN) and total sulfer (TS) contents show the high values, and C/N ratios show the low values. In high density lamina, these parameters had the opposite tendency. These results are suggested that the sediments of high density lamina deposited during the precipitation time.

It compared the lamina and precipitation patterns during 6 years. Relatively high density lamina was identified 116 lamina. On the other hand, the total precipitation of >20mm of 7 days has been observed 108 times. Therefore, if the formation of relatively high density lamina is due to rainfall, it would be formed by the 7 days total precipitation of >20mm. High density lamina set corresponds to when the 7 days total precipitation of >60m is continuously occur in a short term. The combination patterns of lamina and lamina set almost coincides with the precipitation pattern. For this reason, high density lamina are formed during precipitation term.

However, there was no significant difference in the thickness of the high density lamina when low and high precipitation. It is considered that the excess water mass containing the suspension is discharged from the system without being deposited in the lake. Thick high density lamina set, such as those found in this core, seems to be a thick high density lamina in the condition of low sedimentation rate. A thick high density lamina correspond to when the annual precipitation amount is large. Therefore, there will be possibility of estimating the degree of precipitation by analyzing the thickness of high density lamina.

Keywords: precipitation type lamina, paleo-precipitation, Varve, Lake Mokoto

Pleistocene deep-sea ostracodes at IODP Site U1426 and their implication for paleoenvironments

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In the Sea of Japan, the Quaternary glacial-interglacial climate changes have affected deep ocean floor environments as well as coastal environments and biota [e.g., Kitamura and Kimoto, 2006, Palaeogeogra., Palaeoclim., Palaeoeco., 236: 355–366; Watanabe et al., 2007, Palaeogeogra., Palaeoclim., Palaeoeco., 247, 50 –64]. Little is known about the Pleistocene deep-sea ostracodes and their response to environmental changes. We present Pleistocene ostracodes at IODP Site U1426 (37°2.00′N, 134°48.00′E; 903 m water depth). Twenty-one taxa were obtained from 87 Pleistocene (2.0–1.2 Ma) sediments of the interval between 123.50 and 218.14 mcd. Ostracodes occur from sediment samples with L* values of more than 33. Benthic ostracode accumulation rates (BOARs) exhibit less than 14 ind/cm^2/kyr. At 180 mcd, BOARs show a change: BOARs indicates maxima of 0.6–4.2 ind/cm^2/kyr above 180 mcd (~1.7Ma), whereas BOARs show maxima of 1.7–14 ind/cm^2/kyr below 180 mcd. *Acanthocythereis dunelmensis*, *Krithe antiswanensis*, *Krithe hemideclivata*, *Krithe reversa* , and *Robertsonites tabukii* are found ubiquitously. The ostracode fauna indicates oxic condition, alternation of export productivity, and possibly warm water-mass. Generally ostracodes are sensitive to oxygen contents. Their population vanishes in condition with oxygen contents of less than 0.4 ml/l O_2[Dingle, 1995, Mar. Geol., 122, 207–225]. We infer that the sediments with high L* values (>33) were deposited at oxic condition (> 0.4 ml/l O_2). Because BOARs are influenced by export productivity [Yasuhara et al., 2012, Paleobiol., 38, 162–179], the change in BOAR at 180 mcd suggests alternation of export productivity. According to Kitamura (2009, J. Quat. Sci. 24, 880–889), who discuss the surface and intermediate water-masses during the Pleistocene, the flow of the Tsushima current was intensified after 1.7 Ma. The change in surface water-mass probably made effects on surface productivity and benthic ostracodes. *R. tabukii* [= *R. reticuliforma* of Ozawa, 2003, Paleontol. Res., 7, 257–274], that lives in seafloor environments with water depth of 150–250 m and temperature of 2–5°C, indicates a warmer water-mass that the modern intermediate water with 0–1°C temperature.

Keywords: Sea of Japan, Ostracoda, Pleistocene, Deep sea

Reconstruction of paleoceanographic environment using planktonic foraminifera fossils from the Mera Formation of the Chikura Group distributed in the southern most part of the Boso Peninsula

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The Mera Formation of the Chikura Group, distributed in the southern most part of the Boso Peninsula, is thought to be deposited during from the late Pliocene to the Early Pleistocene including the Northern Hemisphere Glaciation (NHG) onset time (Kotake et al., 1995). Because the Boso Peninsula faces the Kuroshio-Oyashio convergent area, the Chikura Group seems to have sensively recorded paleoceanographic variations during the time. The aim of this study is to recnstruct the paleoceanographic environment off the Boso Peninsula during the onset time of NHG by assemblage analyses of planktonic foraminifera fossils and paleotemperature estimation using a transfer function method.
In this study, we used rock samples taken from 40 horizons in a succession at the middle part of the Chikura Group which corresponds to a period of 2.30-3.14 Ma defined by Tokoro et al. (2011) and Okada et al. (2012). We have extracted foraminiferal tests from collected rock samples by the sodium sulfate method, and identified a total of 10 genera 27 species of planktonic foraminifera fossils.
We reconstructed an influence of water mass from geographical zones (Arctic, Subarctic, Transition, Subtropical, Tropical), which are regulated by the water temperatures, deduced by a characteristic species assemblage observed at the each zone.
In addition, we performed a principal component analysis on the identified planktonic foraminiferal assemblage data to estimate water mass contribution and quantitative reconstruction of water temperature based on the method using factor loadings and a transfer function proposed by Takemoto and Oda (1997). As the result, we estimated that the cause of cooling at 3.1-3.0 Ma was by the influence of a cold water mass or the Tsugaru current, cooling at 2.7-2.5 Ma was by a domination of the Oyashio current, and warming at 2.5-2.3Ma was by the weakening of the Kuroshio current.

High-resolution continuous lithostratigraphy of middle to upper Miocene in Yurihonjo, Akita

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The middle to late Miocene is the time of global cooling. According to Lear et al. (2000), who reconstructed changes in the volume of ice sheets during the past 50 My, expansion of the ice sheets occurred in three steps during Cenozoic, and the second step approximately at 14 Ma was significant one due to the growth of the east Antarctic ice sheet.
During the middle Miocene, the east Antarctic ice sheet expanded and stabilized, which probably caused the change in global deepwater circulation pattern. Simultaneously, the organic carbon-rich siliceous sediments including the Monterey Formation and the Onnagawa Formation started widely accumulating in the coastal area of the Pacific Rim region. Deposition of these organic carbon-rich sediments might have drawn down the atmospheric CO_2, thus acting as a positive feedback to accelerate global cooling. These sediments are also known as a petroleum source rock. Thus it is important to study the origin and nature of these sediments as well as the timing and extent of their deposition.
In the process of expansion of Antarctic ice sheet and global cooling during the Middle Miocene, orbital-scale changes in $\delta^{18}O$ have been amplified and associated with switches between dominance of 100 ky cycles and 41 ky cycles (e.g. Holbourn et al., 2007), suggesting instability of the climate system. Tada (1991) reported the occurrence of centimeter-scale black-white banding observed in the siliceous rocks of the Onnagawa Formation, which he interpreted as reflecting millennial-scale changes in paleoceanography that could have been related to instability of the climate system. Thus, it is important to study the origin and variability in the composition and texture of the Onnagawa and the overlying Funakawa formations. To study the orbital to millennial-scale variabilities in the Onnagawa and Funakawa Formations and their temporal changes during the middle to late Miocene, it is critical to reconstruct a continuous sequence of the Onnagawa and Funakawa formations.
To accomplish this objective, we established a nearly continuous sequence of the Onnagawa and Funakawa formations with 1 ky-scale resolution. The research was conducted on the Kubota-river north route in Yurihonjo city, Akita, on which parts of the sequence of the Onnagawa and Funakawa formations are exposed repeatedly. The result are integrated with columnar sections constructed at the Ushigoe and the Yagiyama routes 11 km to the southwest of the studied area by Kurokawa (2015MS). A composite columnar section is constructed, which revealed the occurrence of the black-white banding intervals and termination of the siliceous sediments deposition (the Onnagawa/Funakawa boundary). We also extracted microfossils from the sequences to develop the better age model. The result will be presented at the meeting.

Keywords: Miocene, Siliceous rocks, the Onnagawa Formation, the Funakawa Formation

Paleoenvironmental records in sclerosponges from the Ryukyu Islands, Japan

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Sclerosponges, living in dark environments of tropical to subtropical shallow oceans, precipitate calcium carbonate skeleton with growth bands. They grow slowly at an approximate rate of <1 mm/year unlike corals (~1 cm/year) but can be so long-lived for several decades to hundred of years like corals. Skeletal oxygen isotopic ratios reflect variations in sea surface temperature and seawater with the latter being closely related to salinity reflecting the precipitation-evaporation balance at the sea surface and changes in water mass transport. In contrast to zooxanthellate corals, which occasionally show positive correlations between skeletal oxygen and carbon isotopic ratios, there do not exist vital effects in the secretion of sclerosponge skeleton. Previous studies showed significant decrease trends in the carbon isotope records of sclerosponges and corals toward the present, which is probably a result of isotopically-light carbon dioxide had been added into the atmosphere/ocean from fossil fuel burning. Therefore, sclerosponges are shown to provide annually resolved time series of proxy records of the ocean environments since the Industrial Revolution. However, longer (>100 year) proxy records from sclerosponges were derived only from material examined from the Atlantic Ocean. Here we present oxygen and carbon isotope records from sclerosponges collected from Kume-jima, Okinawa-jima, and Miyako-jima, the Ryukyu Islands in the North Pacific. Soft X-ray images showed highly developed skeletal growth bands with >100 high/low density layers. The secular changes in carbon isotopic composition of the sclerosponges were consistent with previously reported data from the Atlantic and the Pacific corals and sclerosponges. The long-term oxygen isotopic trends of the samples are characterized by slight depletions throughout their living periods, indicative of an overall trend toward warmer ocean environment around the Ryukyu Islands. Our sclerosponge-based estimates of the sea surface temperature and salinity may document thermal and hydrologic variations in the Ryukyu Islands, furthering a better understanding of northwestern tropical-subtropical Pacific climate change for the last several centuries in conjunction with coral-based long proxy records.

Keywords: sclerosponge, skeleton, oxygen isotope composition, carbon isotope composition, paleocean, the Ryukyu Islands

Assessing of variation of the Indonesian throughflow using a coral core collected from Seribu Island, Indonesia.

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The Indonesian throughflow (ITF) runs from the Pacific into the Indian Ocean through the Indonesian archipelago. The ITF varies heats and water budget between the Pacific and Indian Ocean, and may affect on variations of the El Niño/Southern Oscillation (ENSO) and Asian monsoon. In addition, there is a seasonal surface current corresponding to the monsoon in this area. During the northwest monsoon from January to March, the eastward surface current carries seawater with low density and salinity from the Java Sea into the surface layer of the southern Makassar Strait, and this low salinity water, which is called “freshwater plug”, restrain transportation of ITF in the surface layer of the Makassar Strait. Conversely, during the southeast monsoon, the westward surface current removes the “freshwater plug” from the southern Makassar Strait, therefore, the transportation of ITF in the surface layer of the Makassar Strait is not restrained. Since the behavior of the “freshwater plug” alters heat transportation from the Pacific into the Indian Ocean in the surface, it may influence the Asian monsoon and the Indian Ocean dipole [Gordon et al., 2003]. Then, in this study, we analyzed geochemical tracers used as water temperature and salinity in the coral core which grew up in the Java Sea where is affected by the “freshwater plug”. Consequently, we reconstructed sea surface temperature and sea surface salinity for about 20 years during 1982–2003. We will discuss these reconstructed marine environments in relation to variation of the “freshwater plug” and ITF.

Coupled oxygen isotope records of inclusion water and carbonate from a stalagmite in Hoshino Cave, Okinawa

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Millennial scale abrupt climate changes have been occurred during the last deglaciation. However, the land climate change in Japan is unclear due to sparsity of the high-time resolution paleoclimate record. In this study, we have measured isotope ratios of fluid inclusions and the calcium carbonate of a speleothem in a subtropical island. A stalagmite sample (HSN2), which was broken during a construction work of tourist corridor, was collected in Hoshino cave at Minami Daito Island, Okinawa Prefecture. Isotope ratios of the fluid inclusions were measured using the CRDS-based isotope measurement system. The analytical method was based on Uemura et al. (GCA, 2016), but the most of processes has been automated. The stalagmite covers the last deglaciation period (13-21 kyr). Water content of the stalagmite significantly differs in each layers. The water content correlates with the pattern of stripes of the cross section of the sample. There are weak correlation between the oxygen isotope ratio of the fluid inclusions and that of calcium carbonate.

Keywords: speleothem, stalagmite, isotope, fluid inclusion

Oxygen and hydrogen isotope analyses of fluid inclusions in Holocene stalagmite from Niigata prefecture

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The climate in East Asia is influenced by the East Asian Winter Monsoon (EAWM). Recently, the EAWM variations during Holocene have been revealed by the oxygen isotope ($\delta^{18}O$) record of stalagmite calcite from Fukugaghuchi cave (Sone *et al.*, 2013). In this study, we show oxygen and hydrogen stable isotopes of fluid-inclusion water in the stalagmite. The stalagmite (FG01) in Fukugaguchi cave in Niigata, Japan (Sone et al., 2013) was used for fluid inclusions analyses. The analytical method was based on Uemura et al. (2016), but most of operations were automated. Although water content of FG01 was very low (average 0.006 wt.%), fluid-inclusion isotope data covering 4000-8000 yrs BP were measured successfully.

Keywords: Speleothem, stalagmite, fluid inclusion, stable isotope

cave air monitoring and oxygen isotopic variation in drip water at Inazumi Cave, Oita, Japan

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Variation in oxygen isotopic ratios of stalagmite has been used as useful proxy for reconstruction of rainfall amount and pattern since drip water forming the stalagmite is originated from meteoric water. The original value of isotopic ratios in the drip water is controlled by the meteoric water, however, the final isotopic composition of the drip water is determined by in-cave processes such as evaporation and CO_2 degassing. Therefore, it is important to understand how the initial $\delta^{18}O$ of the drip water is changed by the in-cave processes before it is imprinted in the stalagmite.

Here, we conducted 3 days and 2 nights cave air monitoring and sampling the drip water at Inazumi Cave, Oita, Japan from February to December, 2014. For the cave air monitoring, cave air temperature, relative humidity and cave air CO_2 were measured. For sampling the drip water, the drip water before and after hitting on the handrails was collected in daytime and midnight during the monitoring periods. The meteoric water was sampled outside and near Inazumi Cave monthly. $\delta^{18}O$ and δD were measured for both the drip water and the meteoric water and HCO_3^- was measured for the drip water.

As a result, while the cave air temperature and relative humidity were stable through a whole year, the cave air CO_2 showed distinct seasonal variation, indicating that the cave air CO_2 might be the key to control both CO_2 degassing and kinetic fractionation of $\delta^{18}O$ of the drip water. While HCO_3^- showed seasonal and sequential variation as the cave air CO_2 was lowered, $\delta^{18}O$ and δD did not show, indicating that CO_2 degassing does not strongly affect $\delta^{18}O$ of the drip water as kinetic fractionation or that CO_2 hydroxylation and hydration might dominate in the drip water to maintain isotopic equilibrium.

$\delta^{18}O$ and δD of the drip water was plotted on or close to meteoric water line made by the meteoric water sampled around Inazumi Cave, indicating that the drip water is originated from the meteoric water around Inazumi Cave and evaporation does not affect $\delta^{18}O$ and δD of the drip water. Plus, $\delta^{18}O$ and δD of the meteoric water showed wider variation (-4.69~-13.23‰, -23.12~-101.51‰, respectively) than the ones of the drip water (-7.8~-8.41‰, -54.28~-57.08‰, respectively), indicating that the meteoric water is mixed well in host carbonate rock and homogenized drip water is produced. The mean value of $\delta^{18}O$ and δD of the drip water was the closest to the one of MJJASO (from May to October) of precipitation, indicating that the $\delta^{18}O$ and δD of the drip water might be controlled by summer season precipitation, which dominates approximately 80% precipitation amount out of all precipitation around Inazumi Cave.

$CaCO_3$ farming is now in progress at Inazumi Cave and $\delta^{18}O$ of precipitated $CaCO_3$ and the feeding water will be compared hereafter to check if isotopic equilibrium is maintained between them or not.

Keywords: stalagmite, δD and δ18O, paleoclimatology, drip water, meteoric water, isotopic equilibrium

Centurial-scale cycle observed in oxygen isotope of Holocene stalagmites from central Gifu Prefecture, Japan

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We report the Holocene oxygen isotope profiles successfully obtained from two stalagmites in Gujo City, Gifu Prefecture, where meteoric oxygen isotope appear distinct seasonal pattern (low in winter and high in summer). Holocene sections of stalagmite OT02 (5.3 cm thick) and OT03 (15.3 cm) from exhibit more than 10 cyclic changes in its oxygen isotopic values in a period of 11-2 ka. Estimated ~650-yr wave length broadly conforms with that of solar activity reconstructed based on radio carbon anomaly. The periodicity is also conformable with historical climatic periods, such as Little Ice Age and Medieval Warm Period. Temperature change was unlikely responsible for the stalagmite isotope because the phase unmatched with the solar activity. The stalagmite oxygen isotope was low during the cold phases of lower solar activity, and likely records the change in average isotopic composition of the meteoric water. Meteoric water samples collected at a reference site (Ogaki City) clearly indicate seasonality in the oxygen isotope values. Meteoric waters in winter generally record low isotopic values, likely owning to the Rayleigh distillation that occurs in water vapor mass from the Japan Sea. The stalagmite records at Gujo can be the change in the winter proportion of meteoric water. This would have increased the stalagmite oxygen isotope during colder periods. Similar centurial-scale cycles appear in the Holocene stalagmite from Mie Prefecture. We suggest that such cyclic change can be extended back to Yanger Dryas.

Keywords: stalagmite, Holocene, oxygen isotope

On the possibility of tree-ring $\delta^{18}O$ in Java, Indonesia for paleoclimate proxy

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The Indonesian region plays a key role in global climate system because active convection in this region is considered as a heat and moisture source which drives global circulation. Although $\delta^{18}O$ in tree-ring has been used to reconstruct hydroclimatic and atmospheric circulation, there are only a few paleoclimate reconstruction based on $\delta^{18}O$ in tree-ring in Indonesia (Schollaen et al., 2013, Poussart et al., 2004). In this study, we measured tree-ring $\delta^{18}O$ in Java Island to explore the possibility of tree-ring $\delta^{18}O$ as proxy.
We used four teak (*Tectona grandis*) samples collected at Sumedang, Western Java. Samples were cut into annual rings after cellulose extraction. $\delta^{18}O$ of individual rings were measured by TCEA-IRMS. We analyzed 59 years (1940-1998). Time series variation of $\delta^{18}O$ are correlated between the four samples, and EPS (expressed population signal) values are 0.89-0.93. In addition, the $\delta^{18}O$ time series of this study (Western Java) are very similar to that of Schollaen et al.(2013) (Eastern Java). This suggests common climate signals preserved in teak tree-ring in Java Island. $\delta^{18}O$ time series of our samples shows positive correlation with that of precipitation in the last dry season and negative correlation with that of precipitation in rainy season (growing season). Schollaen et al. (2013) suggests this is because dry season precipitation has relatively high $\delta^{18}O$ compared with rainy season precipitation.
We checked the correlation with DMI (Dipole Mode Index). The results show tree-ting $\delta^{18}O$ in Western Java has a negative correlation with last dry season DMI. This is probably because DMI has a negative correlation with dry season precipitation in Java Island (Ashok et al., 2003).
For future plan, we are going to analyze using tree-ring isotope model, in order to assess the reliability of tree-ring $\delta^{18}O$ as climate proxy in Java.

Keywords: tree-ring, paleoclimate, Indian Ocean Dipole

Basic Study of Paleoclimate Reconstruction Using Width of Teak Annual Rings in Java, Indonesia

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Tree ring has been regarded as one of the useful paleoclimate record media and measuring tree-ring width, among several proxies such as $\delta^{18}O$ and $\delta^{13}C$, is one of the approaches to reconstruct and interpret the history of precipitation at high and mid latitude. At low latitude, teak has been widely used for paleoclimate reconstruction because teak is the one of few trees that can make tree rings. The tree ring of teak is, however, not growing in a concentric fashion and the width on the disk might have bias from place to place. Although some previous researches (e.g., D'Arrigo et al., 1994; Schollaen et al., 2013) showed positive relationship between teak's tree-ring width and precipitation at Indonesia, the measuring methods of these researches do not take the bias of tree-ring width into account.
Here, we developed new measuring methods to improve the issues above and to reconsider if teak's tree-ring width can reconstruct paleoclimate such as precipitation. Two different measuring approaches were developed: "method of approximation as circle or sector (method 1)" and "method of approximation as trapezium (method 2)". Four teak samples were used: one of them is from Dungus area and the others are from Cepu, Indonesia.
As a consequence, method 1 was larger than method 2, and this might be because the boundaries of tree rings have curved and the length of boundaries were long. With method 1 and method 2, we developed tree-ring index as D'Arrigo et al. (1994) and Schollaen et al. (2013) have done and the tree ring index was made by two ways: three-year and five-year running average. The result showed that both method 1 and method 2 showed the mostly the same in all the samples by each running average, indicating that both method 1 and method 2 can be applied as the tree-ring index. Besides, $\delta^{18}O$ of all samples also showed mostly the same values between individual samples, showing the possibility that not only tree-ring width but also $\delta^{18}O$ can be used for determining the date of tree-ring.
Moreover, the tree-ring index showed the following correlation with the following climate factors; positive correlation between two samples and precipitation in early rainfall season, which is consistent with Schollaen et al. (2013); positive correlation between all four samples and dry season Southern Oscillation Index (SOI) and between three samples and rain season SOI, which is consistent with Murphy and Whetton (1989); negative correlation between three samples and one-year average (August to July) SOI; and negative correlation between two samples and dry season DMI.
As describe above, teak seems to be useful for paleoclimate reconstruction. It is necessary to be further verified by additional data from other teak samples in other area.

Keywords: tree ring, tree-ring width, dendroclimatology, dendrochronology

How did climate variations affect rice yields in Early Modern Japan? -comparison between tree-ring oxygen isotope data and Menjo (tax bill) records

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Recent progress in paleoclimatology enables us to investigate how climate changes affected society in the past, in collaboration with historical documents and/or archeological records. For example, Buckley et al. (2010) show that multi-decadal variations in hydroclimate are considered to be a contributing factor in the demise of Angkor. However, it is challenging to investigate how climate changes affected crop yields, which are directly linked to human life.

In the present study, we explored the relationship between climate variations and rice yields using tree-ring oxygen isotope ratios and Menjo (tax bill sent from a local load) records in Early Modern Japan. A tree-ring oxygen isotope chronology was established using several trees collected from central Japan. By comparing with instrumental climate data, the chronology showed a significant negative correlation with summer precipitation and relative humidity. On the other hand, annual rice yields were estimated using Menjo records collected from a total of four villages, which were located along lakefront of Biwa Lake. Specifically, numerical data of Nokoridata, which is closely related to rice yield, were extracted from the Menjo records.

The tree-ring oxygen isotope data showed a significant positive correlation with mean rice yields estimated from Menjo records of four villages, indicating that increase in precipitation leaded to rising lake level of Biwa Lake, which in turn resulted in reduction of rice yields due to floods of crop fields.

(Reference)

Buckley, B. M., K. J. Anchukaitis, D. Penny, R. Fletcher, E. R. Cook, M. Sano, L. C. Nam, A. Wichienkeeo, T. T. Minh, and T. M. Hong (2010), Climate as a contributing factor in the demise of Angkor, Cambodia, *PNAS*, *107*, 6748-6752.

Keywords: tree ring, historical document, rice yield

Diagnose oscillation properties of $\delta^{18}O$ embeded in ice cores from Antarctica and Greenland

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Analysing water stable isotopes is one of the ways to understand global climate change in the past. The temperature proxy using ice cores has been established in glaciology, and is defined as oxygen isotope $\delta^{18}O$. The objective in our presentation is to investigate the relationship between the temperature proxy, $\delta^{18}O$ and solar activity.

Periodicities in an annual ice-core $\delta^{18}O$ record (Graf et al. 2002) obtained from Dronning Maud Land (DML), Antarctica, were examined. We obtained 21-year and 194-year cycles in the data with Fourier and Autoregressive model time series analyses. We will also discuss significance for the obtained power peaks and their relation with the known solar modulation cycles about 22-year and 200-year.

DML ice-core might be affected by the cosmic rays that directly reflected the solar magnetic activity. We will also analyze a Greenland ice core for comparison.

Keywords: oxygen isotope ratio, ice cores

Depositional evidence for the Kamikaze Typhoons from Western Kyushu, Japan

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In the late 13th century, Kublai Khan, ruler of the Mongol Empire, launched what was at the time the world's largest armada in an attempt to conquer Japan. Early narratives describe the decimation/dispersal of these fleets by the "Kamikaze" of 1274CE and 1281CE– a pair of intense typhoons sent by the gods to protect Japan from invasion. Preserved wreckage provides evidence for the larger of the Mongol defeats; however, the probability of two major typhoons impacting this area in such close succession today is relatively low. Here we present a 2000 yr sedimentary reconstruction of typhoon overwash from a coastal lake near the location of the Mongol invasions (Lake Daija). Two marine-sourced flood deposits date to the Kamikaze typhoons and are the events of record in the reconstruction. Results from an additional nearby lake (Lake Kawahara), provide secondary depositional evidence for the events in the form of an extreme freshwater discharge event, thus helping to delineate deposits as storm-induced rather than tsunamigenic. The complete Daija reconstruction indicates greater regional typhoon activity relative to modern beginning around 250CE and extending past the timing of the Kamikaze events to 1500CE. It is difficult to conclusively attribute a pair of extreme weather events to varying climate. However, our results support the occurrence of two major typhoons in the late 13th century near the site of the Mongol invasions and show that extreme events of this nature were more frequent during the timing of the invasions as compared to present day. The role of the paired Kamikaze typhoons in preventing the conquering of Japan by the Mongol fleets may therefore serve as an important example of how an increase in severe weather associated with changing climate has helped to shape major geopolitical boundaries of today.

Keywords: Typhoons, Tropical Cyclones, ENSO, Coastal Flooding

Storm beds of the Ashiya Group and climatic change at 29Ma

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The Oligocene Ashiya Group, distributed in North Kyushu, consists entirely of marine sediments in back arc basin prior to the opening of the Japan Sea. It is divided into the Yamaga, Norimatsu, Jinnoharu Sakamizu and Waita Formations. The sequence boundary was recognized between Norimatsu and Jinnoharu Formations which is assigned to ca. 29 Ma based on the U-Pb age dating of zircon in intercalated tuff. This sequence boundary is thought to correspond to the largest sea level fall in Haq curve during the mid-Oligocene. The aim of this study is to describe the sedimentological characteristics of the thick-bedded storm beds in the Jinnoharu Formation above the 29 Ma sequence boundary, and to compare wavelength, amplitude and thickness of the storm beds of the Jinnoharu Formation with those of Waita Formation.

The Jinnoharu Formation represents some parasequence sets of shoaling upward, ranging from lower shoreface to upper shoreface environments. The parasequence set begins with ravinement deposits at base, passes to alternating beds of sandstone and siltstone, amalgamated thick storm beds, and ends with Ophiomorpha sandstone. The amalgamated storm beds succession is about 10 meters thick with intercalations of slump bed at bottom and two lenticular Ophiomorpha burrow horizons. Hummocky and/or swaley cross-stratification, sub-parallel lamination and multi-grading lamination are well identified internally. The average thickness of each storm beds in the Jinnoharu Formation attains to about 85 cm, whereas that of the Waita Formation reduces to less than half, about 31 cm. In addition, the wavelength and amplitude of storm beds of the Jinnoharu Formation is larger than those of Waita Formation. The relationship between bed thickness and wavelength of storm beds in both the Jinnoharu Formation and the Waita Formation shows linear relationship of the exponential function, suggesting that bed thickness and wavelength of storm beds were controlled primarily by intensity of storm waves. These observations suggest that potentiality higher frequency and strength of storm activity during the deposition of the Jinnoharu Formation, just after the large sea-level fall of 29Ma, than that of Waita Formation.

Sudden depositional environment changes above the 29 Ma sequence boundary can be also observed in the Nichinan Group in South Kyushu and Nishisonogi Group in West Kyushu. Beginning of deep sea fan sedimentation in the Nichinan Group and increasing of hyperpycnal sedimentation with abundant siderite nodules and orthoqartzite pebbles in the Nishisonogi Group are thought to be related to the frequent flooding on land from paleo-Asian continent. Such a remarkable change of sedimentation in various environments from coastal, shelf to deep sea deposits across the 29 Ma sequence boundary suggests that drastic climatic change in relation with the glaciation of Antarctica during the Oligocene.

Search for the ejecta deposits of the 0.79 Ma impact (source of Australasian tektite) in NE Thailand

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Impacts of extraterrestrial bodies can cause catastrophic effects on Earth's environment. For example, the Cretaceous-Paleogene mass extinction event was accepted to be caused by the impact of an asteroid of ca. 10 km in diameter (Alvarez et al., 1980; Schulte et al., 2010). A large extraterrestrial impact produces a crater and spreads pulverized, melted, and vaporized rock over large areas forming an ejecta layer. The morphology and the size of the impact crater and the distribution pattern of the ejecta depend on the size, velocity, and angle of the impacting body. Therefore, a crater and an ejecta layer provide information on the nature of the impact event (Melosh, 2011; French, 1998). Ejecta deposits contain shock indicater such as tektite and shocked quartz. Tektites are spherical glassy droplets solidified from the melt of the target rock formed by impact events (Glass and Simonson, 2012; McCall, 2001). Tektites are reported from 4 limited areas called strewn fields and the source craters for 3 out of 4 strewn fields were discovered. The exception is Australasian tektite strewn field, the largest and the youngest strewn field among the four, whose source crater is not yet discovered although its location is estimated as in the east part of Indochina Peninsula (Glass and Koeberl, 2006; Ma et al., 2004; Prasad et al., 2007; Schnetzler, 1992). Consequently, the nature of this large impact event (the size of the source crater is estimated as about 40 km in diameter by Glass and Koeberl (2006)) is not well understood. Although microtektite layers were identified at many marine sites, the ejecta layer has never been identified on land.This is one of the reasons why the source crater has not been found. There are several sites where Australasian tektites are reported from a reddish brown gravel layer called "laterite" layer or the base of the overlying muddy sand layer in NE Thailand (Fiske et al., 1996, 1999; Songtham et al., 2011, 2012; Tamura, 1992). However, the presence of tektite (and/or shocked quartz) is not enough to identify the ejecta deposit because of the possibility of re-deposition (Fiske et al., 1996; Koeberl and Glass, 2000; Langbroek, 2015).Size distribution analysis, petrographic observation and chemical composition analysis of spherical grains were conducted on samples obtained from the basal gravel layer under the "laterite" layer, the "laterite" layer and the muddy sand layer that overlies the "laterite" layer at Krahad and Kok Yai sections in NE Thailand to explore the evidence of impact.The preliminary result of examination will be presented at the meeting.

Keywords: extraterrestrial impact, Australasian tektite, Shocked quartz

Distributions of long chain diols in modern sediments from the Seto Inland Sea: Implications for paleoenvironments

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Long chain diols are widely distributed in both marine and freshwater environments. Previous studies have been proposed the use of long chain diols as paleoenvironmental indicators. Various ratios of C_{28}–C_{32} 1,13-, 1,14- and 1,15-alkyl diols have been proposed as markers for freshwater influence or upwelling (Diol index; Versteegh et al. 1997; Rampen et al., 2008; 2014), as well as a proxy for the past sea surface temperature (Long chain diol index; Rampen et al., 2012). Several distinct organisms have been suggested as biological sources for long chain diols; i.e. marine and freshwater Eustigmatophyte algae (1,13- and 1,15-alkyl diols) and the marine diatom genus *Proboscia* (C_{28} and C_{30} 1,14-alkyl diols).
In the present study, we investigate the long chain diol compositions in the surface and subsurface sediment cores from the Seto Inland Sea to examine the relations of diol compositions and environmental factors in the coastal region. The cores were taken from Osaka Bay and Harima-nada Bay (eastern part of Seto Inland Sea), in which lengths are 20 cm and 40 cm, respectively. These cores are divided and analyzed in every 5 cm (12 samples).
The long chain diols predominantly consist of C_{30} and C_{32} 1,15-alkyl diols in both Osaka Bay and Harima-nada Bay. Low abundance of C_{28} and C_{30} 1,14-diols implicates the occurrence of the diatom genus *Proboscia* in Seto Inland Sea, however its siliceous tests have not been identified. The rest of long chain diols are probably derived from Eustigmatophyte algae or the other unknown producers.
A ratio between C_{30} and C_{32} 1,15-alkyl diol is clearly different between Osaka Bay and Harima-nada Bay, while the general distributions of long chain diols are not significantly varied with depth within each location. The relative abundance of C_{32} 1,15-alkyl diol is higher than most marine sediments reported in previous studies, which possibly attributed to the strong influence by riverine input due to the vicinity to the Yodo River estuary.
Rampen et al., 2008., Earth Planet. Sci. Let. 276, 207–213.
Rampen et al., 2014. Geochim. Cosmochim. Acta 144, 59–71.
Versteegh et al., 1997, Org. Geochem. 27, 1–13.
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Keywords: Long chain diols, Eustigmatophyte, algal biomarker, modern sediment, coastal area, Seto Inland Sea

Comparison between fossil diatom assemblages and algal biomarkers in modern sediments from Seto Inland Sea.

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Microalgae play an important role as a primary producer, and are known as useful environmental indicators in the hydrospheric ecosystem. However, most of the microalgae except diatom have decomposable tests and are hardly preserved in the sediment so that it is difficult to reconstruct their temporal change. Organic molecules (biomarkers) are recently used as another indicator to evaluate the dynamics of primary producers and to reconstruct paleoenvironments. There, however, has few investigations for correlations between monitoring data for algal production, fossil assemblage, and biomarker compositions in the field. Seto Inland Sea underwent human-induced, eutrophication after the WWII, and drastic change of eutrophication was well recorded in the sediment. In the present study, we investigate the fossil diatom abundances and biomarker concentrations in surface and subsurface sediment cores from Seto Inland Sea. The cores were taken from Osaka Bay and Harima-nada Bay (eastern part of Seto Inland Sea), in which lengths are 20 cm and 40 cm, respectively. These cores are divided and analyzed in every 5 cm (12 samples). Although the precise age of the core has not been determined yet, it could be deposited for several decades, according to the sedimentation rates by previous study (Yasuhara *et al.*, 2007).
Diatomaceous species such as small *Thalassiosira* spp. and *Neodelphyneis pelagica*, which were reported by previous study (Hirose *et al.*, 2008), are observed as the dominant taxa in all samples. The valve contents (valves / 1 g dry sediment) are higher in sediments from the Osaka Bay than Harima-nada Bay, indicating variations of their productivity. The vertical distribution of valve content show a increasing trend reflecting eutrophication in Harima-nada, on the other hand, it doesn't show clear trend in Osak Bay. To the contrary, the concentrations of steroids (except dinoflagellate-derived dinosterols), which are synthesized in eukaryotic microalgae, are higher in Harima-nada Bay than Osaka Bay, and decrease toward the upper layers. Futhermore, highly branched isoprenoids (HBIs), which are biomarkers of specific diatom taxa, shows very similar distributions to those of fossil diatoms. These results suggest the effect of productivity of other algal taxa that are hardly preserved in the sediment as fossils, and the different process of diagenesis of diatom valves and organic molecules. We also discuss the detailed characteristics of each diatom taxa and biomarker molecules which are contained in specific taxa.
References:
Yasuhara et al., 2007., Limnol. Oceano. 69, 225-239.
Hirose et al., 2008 The Quat. Res. (Daiyonki-Kenkyu; in Japanese). 47, 273-285.

Keywords: diatom assemblage, algal biomarker, modern sediment, coastal area, Seto Inland Sea, human-induced eutrophication

Sediment trap samples stored in Kyushu University

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Organic carbon produced by phytoplankton sinks to the ocean interior as sinking particles. This process plays an important role in oceanic carbon cycle. In order to investigate contents and fluxes of the sinking particles, sediment traps, funnel shaped instrument with rotating sampling vials to trap sinking particles, are deployed in the deep-sea. At Department of Earth and Planetary Sciences of Kyushu University, many sediment trap samples collected by Professor Emeritus Kozo Takahashi are archived in a refrigerator (wet sample) and storage (dried filter samples). These samples were collected from around the world, mainly from the North Pacific and its marginal seas. These samples are valuable material to understand oceanic biogeochemical cycles.

Keywords: sinking particles, archive sample

Late Holocene environemtal changes in west Mongolia revealed by the lacustrine sediment analyses

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We present the environmental changes in Northwest Mongolia during the last 3000 years based on the core analyses of the saline water and fresh water lakes.

Keywords: Continental interior Asia, History of terrestrial environments, Solar forcing

Late Quaternary paleoceanographic changes in the northeastern Arabian Sea; Inferred from sedimentary organic matter records.

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The northeastern Arabian Sea is characterized by a widespread midwater oxygen minimum zone (OMZ), between 80 to 1300 m, with oxygen concentrations reaching values of <0.05 mL/L^{-1}at present. In particular, biogenic particle fluxes in this region have experienced large seasonal changes due to strong monsoonal winds in summer and winter. Here we report carbon and nitrogen isotope data for a sediment core (ER-4) collected from this region. Synchronous downcore variations in the δ^{15}N record, which are explained by regional changes in the isotopic composition of subsurface nitrate, and hence denitrification were found. Moreover, these variations are synchronous with Indian monsoon changes during the glacial-interglacial cycles, thereby establishing a link with global climate. We discuss that these climate linked variations in this region that are likely to have experienced marine biogeochemical cycles during the Late Quaternary.

Keywords: Arabian Sea, organic matter, oxygen minimum zone (OMZ), δ15N

Multi-elemental data structure of the Indian Ocean deep-sea sediments recording the early Eocene hyperthermals

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Multiple transient global warming events occurred during the early Paleogene. The most prominent of these events was the Paleocene-Eocene thermal maximum (PETM) at ~56 Ma, which is characterized by a rapid and extreme global warming by 5-8°C, severe ocean acidification, and a distinct negative carbon isotope excursion in the marine and terrestrial realm. In addition, several PETM-like global warming episodes called 'hyperthermals' during the early Eocene period (56-52 Ma), accompanying rapid and pronounced negative excursions in the carbon isotopic composition ($\delta^{13}C$), have also been recognized worldwide recently.
Here we have constructed a comprehensive geochemical data set including major- and trace-element contents, $\delta^{13}C$, and $CaCO_3$ contents of 250 bulk sediment samples taken from ODP Sites 738 and 752, both located in the Indian Ocean. The analytical results show that the sediments of these cores record multiple carbon isotope excursions and reductions of carbonate contents, probably corresponding to the PETM and some of the early Eocene hyperthermals. We apply Independent Component Analysis to the compositional data matrix, and describe the fundamental structure of the multi-elemental data set on the basis of the extracted geochemical independent components.

Keywords: deep-sea sediment, Indian Ocean, climate change, hyperthermals, Independent Component Analysis

The warm climate of the Mid to Late Pliocene as seen in MIROC climate modelling experiments

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These past few years has seen much interest in the modelling of the warm climate of the Mid to Late Pliocene, approximately 3 million years ago. This period represents the most recent time in the earth's history when atmospheric carbon dioxide levels were comparable to those of today. In this sense, it has drawn much attention because of possible parallels with near future climate, helped by the availability of proxy datasets from the ocean and other sources. Recent interest has been further fuelled by The Pliocene Model Intercomparison Project (PlioMIP) which has brought together the paleodata analysis group, PRISM, and various international climate modelling groups to expand the scientific community's knowledge of this period. Now into its second phase, PlioMIP has set out specific protocols for climate model experimental design, utilizing the latest datasets related to Pliocene vegetation, soils, ice distribution and ocean bathymetry, while concentrating on a time-slice to limit temporal uncertainty
We ran several Pliocene climate modelling experiments using the atmosphere-ocean coupled model, MIROC4m. These include experiments using the boundary conditions specified in the first phase of PlioMIP in addition to one which has incorporated most of the latest datasets from the second phase. Zonal mean surface air temperatures increase by about 10 deg C at high latitudes, accompanied by a decrease in the equator-to-pole temperature gradient. As with many other climate models, the polar amplification appears smaller than that suggested by proxy data in PlioMIP. Initial results from experiments using the latest boundary conditions, in particular a closed Bering Strait, suggest that this amplification is further weakened.

Keywords: Pliocene, Climate modelling, Paleoceanography

Paleoceanographic reconstruction using siliceous microfossils from the Atlantic sector of the Southern Ocean

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Abundant siliceous microfossils such as diatoms are often found from the Neogene-Quaternary sediments in the Southern Ocean, therefore, the fossil diatoms give us important information of environmental changes in the past. However, paleoceanographic studies based on diatom analysis that focus on the long-term paleoenvironmental changes are very rare, whereas most studies have dealt with the Last Glacial Maximum and Holocene environments. Furthermore, the other siliceous microfossils such as diatom *Chaetoceros* resting spores and chrysophyte cysts seem to be useful paleoenvironmental indicators to reconstruct changes in the upwelling system and to assess the influence of freshwater to the Southern Ocean.

In this study, the changes in the microfossil assemblages of 'normal' diatoms, *Chaetoceros* resting spores and chrysophyte cysts are investigated in order to estimate a long-term trend of paleoceanographic changes (e.g., changes in sea-ice distribution, and location and strength of upwelling and the Antarctic Circumpolar Current system) around the Southern Ocean. In the current presentation, we would like to present and discuss on the paleontological data derived from the ODP Site 689 and DSDP Site 513 materials (Atlantic sector of the Southern Ocean).

Keywords: the Southern Ocean, diatom, resting spore, chrysophyte cysts, ODP, DSDP

SST variation derived from siliceous microfossils at ODP Site 704 in the Southern Atlantic Ocean for the last 6.3Myrs

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Reconstruction of sea surface temperature (SST) is one of the important keys to estimate paleo CO2 variation. Because alkenone SST proxy in higher latitude ocean sometime shows uncertainties due to low alkenone concentration in sediment samples, the SST dataset based on another proxies should be prepared. Biogeographical distribution of silicoflagellate and some diatom taxa corresponds to distribution of cold and subtropical water masses. At ODP Site 704 (46.9°S, 7.4°E, annual SST 5.6° C) in the South Atlantic Ocean, latitudinal migration of subpolar and subtropical surface water masses were estimated for the last 9 million years based on silicoflagellate and diatom fossils in the sediment core samples. Although the fossil preservation was poor in the oldest period from 9 Ma to ~6.3Ma, the extinct genus *Bachmannocena* considered as a temperate or cosmopolitan species was observed for the period. Continuous silicoflagellate occurrence was observed from ~6.3Ma to present. The silicoflagellate-derived climatological SST was 9°C for 6Ma. The subtropical genus *Dictyocha* intermittently dominated the assemblage from ~6Ma to 4.6Ma. When the *Dictyocha* events occurred, the estimated SST temporally rose to 11-12°C. The co-occurrence of cold and subtropical water species probably reflect that the subpolar/subtropical boundary is located around the studied site. After the *Dictyocha* events, SST decreased to ~4°C from 4.6Ma to 2.1Ma. The relative abundance of sea ice-related species in the silicoflagellate assemblages increased from 2.2Ma. The minimum SST reaching to ~0°C was recorded at 1.9Ma. The SST after 1.8Ma usually ranged from 2.5 to 7.4°C except for three samples characterized by high dominance of subtropical species. Long-term trend of silicoflagellate SST was similar to SST proxies byalkenone and Mg/Ca of planktic foraminifer test. However, silicoflagellate SST was usually 2-4°C lower than other SST proxies, and this difference may be partially explained by different seasonality of silicoflagellates, planktic foraminifer, and calcareous nannoplankton. Further evaluation on our SST data is required for the reliable SST reconstruction at this site.

Keywords: silicoflagellate, alkenone, foraminifer, South Atlantic Ocean

