Impact on planktic foraminiferal test (*G. bulloides*) calcification caused by sea-surface condition

*Shinya Iwasaki[1], Katsunori Kimoto[2], Osamu Sasaki[3], Harumasa Kano[3]

1. National Institute of Advanced Industrial Science and Technology, 2. Japan Agency for Marine-Earth Science and Technology, 3. The Tohoku Univerisity Museum

Discharged anthropogenic CO_2 gas has been accumulating in the oceans, lowering seawater pH (ocean acidification), and could reduce calcification rate of marine calcareous organism. In order to monitor and evaluate the impact on calcareous organisms by ocean acidification, several proxies of calcification intensity of planktic foraminifera based on test weight have been employed, whereas these proxies are controlled by several factors other than seawater carbonate chemistry. Here we employ 3-D physical measurement by X-ray micro CT scanner into living *Globigerina bulloides* (planktic foraminifera) test, evaluate test characteristics (wall thickness, density and calcification rate), and compared them with ambient seawater conditions for the first time. As a result, seawater carbonate saturation state (ΩCa) has the most significant correlation with test density, and seawater temperature has the most significant correlation with test wall thickness. Furthermore, traditional proxy of calcification intensity, based on the test weight measurement, is not controlled by test density but by calcification rate and wall thickness, indicating that these traditional proxies are not suitable to evaluate the impact on living *G. bulloides* calcification from ocean acidification, and 3-D physical measurement by X-ray micro CT must be a powerful tool replacing them.

Keywords: Planktic foraminifera, Ocean acidification, test density

Grain-scale stable carbon and oxygen isotopic variations of the international reference materials IAEA-603 (newly released) and NBS 19

*Kozue Nishida[1], Toyoho Ishimura[1]

1. National Institute of Technology, Ibaraki College

The international reference material IAEA-603 prepared from Carrara marble (calcite) was newly released on 2016 to replace the reference material NBS19 (exhausted). From the reference sheet of IAEA-603 (Fajgelj and Assonov, 2016), assigned carbon and oxygen isotopic ($\delta^{13}C$ and $\delta^{18}O$) values are +2.46± 0.01‰ and -2.37±0.04‰, respectively at a sample size of about 120 μg. For sub-microgram scale isotopic analysis, we examined the grain-scale stable carbon and oxygen isotopic variations of IAEA-603. The individual grains of IAEA-603 (grain size: 200 to 760 μm) were measured with an IsoPrime100 isotope ratio mass spectrometer with customized continuous-flow gas preparation system (MICAL3c, Ishimura et al., 2004, 2008) at National Institute of Technology, Ibaraki College, Japan, and the individual weight of each grain estimated from the reacted CO_2 gas volume was 4-90 μg. The standard deviations (1 σ uncertainties) of $\delta^{13}C$ and $\delta^{18}O$ of the individual grains of IAEA-603 are ±0.07‰ and ±0.16‰, respectively (N = 16), and the grain-scale analytical results also indicated homogeneous values as same as stable isotopes of the single grains of NBS19 (the standard deviation: ±0.10‰ in $\delta^{13}C$, ±0.16‰ in $\delta^{18}O$, N = 16, Ishimura et al., 2008). In IAEA-603, $\delta^{13}C$ and $\delta^{18}O$ ranged within 0.2‰ and 0.4‰, respectively. Both $\delta^{13}C$ and $\delta^{18}O$ of the individual grains showed non-significant grain-size dependencies. From the scanning electron microscope observations, the individual grains of IAEA-603 were dominantly polycrystalline with translucent grains composed of coarse crystals, and contained a certain amount of white opaque grains containing fine crystals. On the other hand, NBS19 showed single-crystal-like grains. Thus, as the reference sheet of IAEA-603 (Fajgelj and Assonov, 2016) mentioned, the storage in sealed ampules is important for avoiding exchange with atmospheric moisture and atmospheric CO_2, especially in polycrystalline IAEA-603.

Keywords: stable isotopes, international reference material, carbonate, IAEA-603, SEM

Isotopic re-equilibration of fluid inclusions in natural speleothem by artificial heating

*Ryu Uemura[1], Yudai Kina[1], Kanako Omine[2]

1. Department of Chemistry, Bioogy, and Marine Science, University of the Ryukyus, 2. University of the Ryukyus

Isotopic compositions of inclusion water in speleothems are promising new climatic proxies. Oxygen isotope ratio of water ($\delta^{18}O$) may provide direct estimate for past temperature changes. Several studies, however, used hydrogen isotope ratio of water (δD) because the $\delta^{18}O$ may be affected by re-equilibration between water and host calcite. Thus, precise knowledge about magnitude and reaction rate of the re-equilibration is needed to evaluate paleoclimate records in speleothems.
To estimate the re-equilibration effect, we measured isotope composition of fluid inclusions in natural stalagmites, which had been heated in laboratory before isotope measurement. Several (3-5) subsamples were cut from the same depth of stalagmites. Then, each sub-sample was heated at different interval (0 –80 hours) under continuous evacuation using a turbomolecular pump. The experiments were conducted under different temperatures of 25 and 105˚C. The $\delta^{18}O$ and δD values of fluid inclusions in a sub-sample were measured using a semi-automated system, which was modified based on cavity ring-down spectroscopy technique (Uemura et al., 2016).
Under the 105˚C hating, the inclusion $\delta^{18}O$ values of a layer show a small increase from the initial value to ca.30 hours heating, and then after that it appears to stay flat. In contrast, the $\delta^{18}O$ value shows no trend under the room temperature. The δD value shows no trend at any experimental conditions, suggesting that loss of inclusion water during long-time evacuation does not cause the $\delta^{18}O$ enrichment. Preliminary data suggest ca. 5% of fluid inclusion water may re-equilibrated with surrounding host calcite at the 105˚C heating experiment. The results prove the existence of re-equilibration effect, but its magnitude is not significant for estimating glacial-interglacial temperature changes.

Keywords: speleothem, fluid inclusion, stable isotope, glacial interglacial cycle

Relationship between climate changes and solar activity in a mid-Holocene stalagmite from Minami Daito, Okinawa

*Kanako Omine[1], Ryu Uemura[1], Kosuke Masaka[1], Ryuji Asami[1], Chuan-Chou Shen[2], Mahjoor Ahmad Lone[2]

1. University of the Ryukyus, 2. Dept. of Geosci., National Taiwan University

Correlations between atmospheric $\Delta^{14}C$ and oxygen isotope ($\delta^{18}O$) record of the stalagmites suggest that the variations of Indian and Asian monsoons are influenced by solar activity during the Holocene (Neff et al., 2001; Wang et al., 2005; Duan et al., 2014). To evaluate the influence of solar activity on a small oceanic island in East Asian monsoon region, we investigate multi-proxy records of a stalagmite from Okinawa, Japan. A stalagmite, HSN1, was collected in Hoshino cave in Minami Daito Island, Okinawa, Japan. The $\delta^{18}O$ of the calcite was measured using Gas-bench IRMS (Delta V advantage). The isotope compositions of the fluid-inclusion water were measured using a semi-automated version of our fluid inclusion analysis system described in Uemura et al. (2016). U-Th dates were measured at National Taiwan University. The HSN1 stalagmite grew from ca. 6,000 to 8,000 years before present with a high growth rate (ca. 130 μm/yr). The pattern of calcite $\delta^{18}O$ variation (e.g., 80-year periodicity) was similar to that of the atmospheric $\Delta^{14}C$.

References:
Neff et al., *Nature*, 411, 290–293, 2001
Wang et al., *Science*, 308, 854–857, 2005
Duan et al., *Scientific Reports*, 4, 5159, 2014
Uemura et al., *Geochimica et Cosmochimica Acta*, 172, 159–176, 2016

Keywords: stalagmite, isotope, solar activity

Paleoclimate records in stalagmites from Okinoerabu-jima, Ryukyu Islands, Japan

*Ryuji Asami[1], Yuji Akamine[1], Hidetaka Genka[1], Ryotaro Matsumoto[1], Ryu Uemura[1], Yasufumi Iryu[2], Chuan-Chou Shen[3]

1. Faculty of Science, University of the Ryukyus, 2. Graduate School of Science, Tohoku University, 3. HISPEC, National Taiwan University

Stalagmites can have continuous deposition of calcium carbonate over long periods of time and well-selected stalagmites are accurately datable with high-precision U-Th dating methods (e.g., Shen et al., 2002). Stable oxygen isotope signatures in stalagmites have been used as a paleoclimate proxy (e.g., McDermott, 2004) because the isotopic values can be controlled by oxygen isotopes of the drip water and the cave temperature (e.g., Hendy, 1971). Since 2000, stalagmite-derived oxygen isotope time series have been widely used to reconstruct hydroclimate variations in East Asian monsoon regions during the Quaternary (e.g., Wang et al., 2001).
Here, we present oxygen and carbon isotope time series of 17 stalagmites collected at 4 caves in Okinoerabu-jima, the Ryukyu Islands, Japan. The Hendy Test performed in this study suggests that the isotope profiles along the center of stalagmite growth appear to be primarily of environmental origin with little effects of kinetic fractionation. Since 2014, we have observed cave environments using loggers and collected water samples to establish relationship between oxygen isotope composition of drip waters and stalagmites. We generate a well-dated time series of the oxygen and carbon isotope ratios in stalagmites using a high-precision U-Th dating method to reconstruct hydroclimate changes around the Ryukyus during the Quaternary, especially Holocene. Coupled with previously published stalagmite records from China (e.g., Wang et al., 2001) and Japan (Shen et al., 2010; Sone et al., 2013; Uemura et al., 2016), our study can allow a better understanding of past spatial climate changes associated with the East Asian Monsoon.

Hendy et al. (1971) Geochim. Cosmochim. Acta, 35, 801-824.
McDermott (2004) Quat. Sci. Rev., 23, 901-918.
Shen et al. (2002) Chem. Geol., 185, 165-178.
Shen et al. (2010) Quat. Sci. Rev., 29, 3327-3335.
Sone et al. (2013) Quat. Sci. Rev., 75, 150-160.
Uemura et al. (2016) Geochim. Cosmochim. Acta, 172, 159-176.
Wang et al. (2001) Science, 294, 2345-2348.

Keywords: stalagmite, paleoclimate, oxygen isotope composition, carbon isotope composition, Holocene, Ryukyu Islands

Mention of a speleothem collected at Iriomote Island –Observation of laminae and laminae counting–

*Tatsuhiko Watanabe[1], Yumiko Watanabe[1], Hiroshige Matsuoka[1], Takahiro Tagami[1]

1. Graduate School of science, Kyoto University

Reconstructing ancient climates can contribute to predicting the future climates, so that there are a lot of studies to reconstruct past climates all over the world using many proxies. Stalagmite is one of the powerful proxies to deduce ancient climates in land area. However, there are few studies where stalagmite is used for the reconstruction in Japan.
A stalagmite grows on the floor of the cave due to the accumulation of CaCO3 deposited from the drip water which comes from groundwater which dissolves the limestone of the host rock. Stalagmites have growth laminae and some of them are annual. In that case, they have annual climate data and we can obtain highly scale paleoclimate data. Moreover, we can obtain high time resolution information from one using U-Th dating method. This high resolution information is also useful to reconstruct past climates.
In this study, we used a stalagmite (TK04) as a sample, collected at Takana Cave in Iriomote Island, Okinawa, Japan, in order to reconstruct the ancient climate around there. As the first step of this study, we performed the observation of its laminae using a transmission microscope and a luminescent microscope, and counted the number of them.
As a result, two types of laminae (type a, b) and one type of structure (type c). Note that a lamina is composed of two parts: transparent part, and black part. In type a, a lamina is occupied by more black part than transparent part, and the width of the lamina is about 50 μm. In type b, a lamina is occupied by less black part than transparent part, and the width of the lamina is about 100 μm or over. In type C, the structure appears to be homogeneous and few laminae are observed. Whereas type a is observed only near the top portion of TK04, type b is observed almost all portions of it, and type c is observed around the hole of TK04.
Because type a is altered to type b clearly, it is assumed that the stalagmite’ s growth was stopped temporarily or the environment of the cave was changed. So we counted the number of laminae near the top portion, where type a is observed. As a result, we observed 15 to 18 laminae there.

Keywords: Paleoclimatology, Stalagmite

Millennium-scale changes recorded in oxygen isotopes of two stalagmites from central Japan

*Taiki Mori[2], Akihiro Kano[1], Kenji Kashiwagi[3]

1. Graduate School of Science, The University of Tokyo, 2. Graduate School of Integrated Sciences for Global Society, Kyushu University, 3. Graduate School of Science and Engineering for Research, University of Toyama

Stalagmite records from Japanese caves based on U-Th dating have demonstrate latest Pleistocen-Holocene change in East Asian summer and winter monsoons. Here, we present a new oxygen isotope record of well dated two stalagmites; KA03 collected from Kiriana cave in central Mie Prefecture and OT02 collected from Otaki cave in central Gifu Prefecture. Results of dating show that the stalagmite has been growing during the last 80 kyr almost continuously.
The oxygen isotopic profile 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). Oxygen isotope of meteoric water collected near the cave shows a seasonal pattern (lower in summer) and an amount effect. Because the locality is generally dry in winter season, we can assume that the stalagmite oxygen isotope is a proxy of humidity in summer. The amount of rainfall had been decreasing gradually from 37 ka to LGM, and then sharply increased at the onset of B/A warming. During the Heinrich events, summer in central Mie Prefecture was relatively dry. The stalagmite KA03 is a novel and significant record of the East Asian summer monsoon.

Keywords: Stalagmite, Last glacial, Oxygen isotopes

Seasonal change recorded in carbonate clumped isotope of tufa deposits

*Shota Amekawa[1], HIrokazu Kato[1], Akihiro Kano[1]

1. Graduate School of Science, The University of Tokyo

Clumped isotope of CO_2 generated by acid reaction of calcite is only dependent on temperature of mineral precipitation (Ghosh et al. 2006). However, this carbonate clumped isotope often offsets from the equilibrate value of an expected temperature likely due to kinetic effect. We applied the clumped isotope to tufa deposits that are generally equilibrate in conventional carbon and oxygen isotopes. Samples were collected at two tufa sites in Ehime and Okayama Prefecture, every month during a period from December 1999 to December 2000 (Kano et al., 2003; Kawai et al., 2006). The analyzed material was collected from the surface of each sample, which is 0.5 mm thick.
The generated carbon dioxide was carefully purified in column cooled at -10ºC, and measured by MAT 253 with applying the background correction of He et al. (2012). Each value was adjusted on the absolute reference frame of Dennis et al. (2011). A typical measuring error was 0.015 permil (1s) that corresponds to 3ºC in the temperature range of Hiro-1. We applied the temperature equation based on our own measurements of synthesized calcites of known temperatures, which is very similar to the theoretical equation of Guo et al. (2009).
The fufas from Ehime Prefecture indicated a clear seasonal changes of temperature ranging from 3.7 to 20.9ºC, which is consistent with measured temperature range of 5-19ºC. A similar consistent result from the Okayama tufa indicates that the carbonate clumped isotope of tufa can be used for a thermometer. CO_2 degassing was observed in these tufa sites, but did not resulted in a recognizable disequilibrium. We suspect that the kinetic effect was insignificant in a pH condition around 8.3 where the dominant carbonate species is bicarbonate.

Keywords: Clumped isotope, tufa, thermometer

A 300-year floating chronology of tree-ring oxygen isotope derived from teak log coffins in northwestern Thailand

*Masaki Sano[1], Akane Tsushima[1], Nathsuda Pumijumnong[2], Zhen Li[1], Takeshi Nakatsuka[1]

1. Research Institute for Humanity and Nature, 2. Mahidol University

Oxygen isotope ratio of tree-ring cellulose is widely used to reconstruct hydroclimate variations in monsoon Asia. Long tree-ring chronologies are required for better understanding of monsoon dynamics. In this context, we developed a 300-year floating chronology of oxygen isotopes using teak log coffins collected at the Ban Rai Rockshelter in northwestern Thailand. Radiocarbon-based wiggle matching for log coffin indicates that the outermost ring was produced in 345-390 CE (2 σ). Spectral analyses reveal significant peaks in 27.0 and 9.3 years as well as 3.8 and 3.5 years, which fall within the range of ENSO variability. Because log coffin culture has long history in this region, a long chronology can be constructed by measuring other coffin samples. In addition, tree-ring data in collaboration with archeological findings will shed more light on the relationship between climate variability and human activities.

Keywords: dendroclimatology, oxygen isotope, radiocarbon dating

The Comparison of the method to measure tree-ring width in dendroclimatology using Teak annual rings in Indonesia

*Takayuki Arai[1], Yumiko Watanabe[1], Ryo Hisamochi[1], Junji Sugiyama[2], Miyuki Matsuo[3], Hiroyuki Yamamoto[3], Toshitaka Tsuda[2], Takahiro Tagami[1]

1. Graduate School of Science, Kyoto University , 2. Research Institute for Sustainable Humanosphere, Kyoto University, 3. Graduate School of Bioagricultural Sciences, Nagoya University

Tree-ring width has been used to establish relationships between tree growth and climate (Fritts 1976). Teak (*Tectona grandis* Linn. f.) has been used for paleoclimate reconstruction in tropical region (e.g., D'Arrigo et al., 1994) because teak is the one of few trees that can make annual tree rings there. 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. Therefore, the discussion of the relationship between tree growth and climate might be influenced by the measurement method of tree-ring width.
In this study, we used three teak disk samples, which were collected in Cepu, East Java, Indonesia. We compared the way of tree-ring width measurement. Three different measuring approaches were developed: "method of back calculation based on area (Method 1)", "method of curve traverse lines (Method 2)", and "method of straight traverse lines (Method 3)". Method 1 is the way as follows: consider two circles, which have the same areas closed in internal and external circumference of a tree ring, and define the difference in the lengths of radius as the tree-ring width. Method 2 is the way of measuring along a pith line (growth line), and Method 3 is the way of measuring along a straight line drown from the center to outside.
First, with Method 1, we calculated tree-ring width, and defined each tree-ring's age by cross dating. Next, we measured along 16 lines for each teak disk with Method 2, and developed tree-ring width index. Here we made two types tree-ring width index: one is to choose one line for each teak disk and to average them (16^3 patterns in all; below is called "One Line"), and the other is to choose two lines for each teak disk and to average them ($({}_{16}C_2)^3$ patterns in all; below is called "Two Lines"). Method 3 can be described alike. In previous research, Poussart et al. (2004) used one core for each 2 teak disk to measure tree-ring width, so in this study, it corresponds "One Line" in "Method 3". Schollaen et al. (2013) used two cores for each 16, so in this study, it corresponds "Two Lines" in "Method 3".
Tree-ring width set with "Method 1" is calculated by the two-dimensional growth, and with "Method 2" and "Method 3" represent the one-dimensional growth directly, so the former mirrors the amount of teak's growth more than the latter does. Thus, we analyzed the correlation between each tree-ring width index and climate data, and ascertained how close the consequence of the latter to the former. We also compared the consequences with previous studies (e.g., Schollaen et al. 2013)
This study showed positive correlation ($p<0.001$) between teak's tree-ring width index and previous year's precipitation in dry season with Method 1, which is consistent with Jacoby and D'Arrigo (1990). With Method 2, the ratio of positive correlation ($p<0.05$) was 96.3% in all cases of "One Line", and 99.9% in all cases of "Two Lines". With Method 3, the ratio of positive correlation ($p<0.05$) was only 44.0% in all cases of "One Line", and 57.8% in all cases of "Two Lines".
Besides, this study ascertained negative correlation ($p<0.01$) between teak's tree-ring width index and previous year's DMI in dry season with Method 1. With Method 2, the ratio of negative correlation ($p<0.05$) was 84.8% in all cases of "One Line", and 95.5% in all cases of "Two Lines". With Method 3, however, the ratio of negative correlation ($p<0.05$) was merely 13.0% in all cases of "One Line", and 10.2% in all cases of "Two Lines".
As described above, tree-ring width with "One Line" and "Two Lines" in "Method 3" might not have

information enough to reconstruct paleoclimate. In addition, “Method 1” seems to be the most effective to reconstruct paleoclimate of the three, and the information of tree-ring width with “Method 2” seems to be more credible than the one with “Method 3”.

Keywords: tree ring, paleoclimate, dendroclimatology, dendrochronology

Measurement of sungkai tree-ring width from Jogjakarta, Indonesia

*Shigenori Iitsuka[1], Yumiko Watanabe[1], Takahiro Tagami[1]

1. Graduate School of Science, Kyoto University

Because equatorial monsoon and ENSO strongly influence on the climate of Indonesia, Indonesia is important place to understand these climate systems. However, modern meteorological observation in Indonesia lacks long-term data and observation stations. Therefore, it is necessary to reconstruct long-term climate changes by using some proxies. In the proxy such as stalagmite and ice core, tree-ring have an advantage that it records climate data with high time resolution.

Paleoclimatological researches using tree-ring have been conducted in Indonesia. Although almost trees in the tropics don’t make tree-rings, teak and sungkai make tree-rings exceptionally. Teak has been studied so far, but there are only small number of studies about sungkai. Understanding differences between responses of teak and sungkai to the climate makes it possible to compare the two species, and that is useful in reconstructing paleoclimate.

In this study, we observed three sungkai disk samples (samiga1, samiga2, samiga3) from Jogjakarta, Indonesia, and measured tree-ring widths in order to increase numbers of studies about sungkai. We confirmed that outermost tree-ring formed in 2014. Because of tree-ring widths and shapes, we presumed that samiga2 and samiga3 was sampled from the same tree. A false ring wasn’t observed in samiga1. Samiga2 had some doubtful rings. By comparing samiga2 with samiga1 and sungkaiNAN7 (Tamura, 2008), we concluded that samiga2 has two false rings. Thus, we concluded that samiga1 has 28 tree-rings, and samiga2 has 37 tree-rings.

However, it is a problem that the number of samples for comparison is small, and sungkaiNAN7 sampled at Serang. To compare sungkai with teak, it is need to analyze more samples from the same area.

Keywords: tree-ring, ring width, paleoclimate

Cellulose oxygen isotopes in Sphagumun from the Bekanbeushi mire, eastern Hokkaido and its application to paleoclimate reconstruction during the last 2000 years

*Hiromichi Sakurai[1], Masanobu Yamamoto[1], Osamu Seki[2], Takayuki Omori[3]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Low Temperature Research Institute, Hokkaido University , 3. The University Museum, The University of Tokyo, Japan

The oxygen isotopic composition of rainfall water has climate signals such as temperature and precipitation. Therefore, we can use the $\delta^{18}O$ values of plant cellulose which preserves the $\delta^{18}O$ values of rainfall water for paleoclimate reconstruction. At the Hani peat mire in northeastern China, paleoclimate reconstruction was attempted using the $\delta^{18}O$ values of cellulose in the peat core, and the variation of the $\delta^{18}O$ values in bulk samples was interpreted that it reflects the variation of temperature (Hong et al., 2009). On the other hands, the analysis of $\delta^{18}O$ in different plant tissues in the same sample from the Rhishiri Minamihama high mire showed that the $\delta^{18}O$ values of *sphagnum* is lower than the other species (Yamamoto and Seki, unpublished data), suggesting that bulk cellulose $\delta^{18}O$ values may have reflected fractional variation in different tissues. In this study, we separated *sphagnum* and plant tissues and measured their cellulose $\delta^{18}O$ for peat core samples retrieved from the Bekanbeushi high mire. The $\delta^{18}O$ values of *sphagnum* were always lower than those of *Vaccinium oxycoccos* and *Calamagrostis neglecta var. aculeolata*. Temporal variation in the $\delta^{18}O$ of *sphagnum* indicated that the value was lower around 1500 years ago and higher around 1100 years ago, corresponding to Dark Age Cold Period and Medieval Warm Period, respectively. The difference of the $\delta^{18}O$ values between plant tisuues and *sphagnum* has a negative correlation with the $\delta^{18}O$ values of *sphagnum.* This suggests that relative humidity was higher in warmer periods, which is analogous to modern summer climate in Bekanbeushi area..

Keywords: peat, cellulose, oxygen isotopes

Variation of Asian dust during Holocene based on the mineral composition of peat sequence in Mt. Daisetsuzan area, northern Japan

*Tomohisa Irino[1], Keisuke Hirai[2], Osamu Seki[3], James Hooper[4], Samuel K. Marx[4]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Faculty of Science, Hokkaido University, 3. Institute of Low Temperature Science, Hokkaido University, 4. University of Wollongong

Asian dust transported to the northern Japan may have a different source from those transported to the southwestern Japan. In spite of this, many of previous dust studies for Asian dust deposition in Japan have been conducted for the paleo-archives collected from the southern area. On the other hand, the Mt. Daisetsuzan area located just below the northern route of Asian dust transport receives a significant amount of dust in spring time, which dies snow surface brown, and the geology mainly consists of volcanic materials. This area is also characterized by well-developed high moors on the mountains covering the last 4000 - 7500 yrs, which would continuously record the history of climate change during the middle to late Holocene. Peat collected from these high moor could be also a suitable material for a precise age determination using the radio carbon, and its inorganic fraction might consist of aeolian dust of continental origin and volcanic materials of the local origin which could be easily distinguished from each other.

In order to reconstruct the Holocene variability of Asian dust deposition in the northern Japan, we collected peat cores from the high moor in the Mt. Daisetsuzan area, and measured the mineral composition contained in peat. After heat treatment of peat samples, we conducted X-ray diffraction (XRD) analysis on the ash fraction and semi-quantified the minerals. Quartz, illite, and chlorite showed positive correlation among others, while various feldspars showed another positive correlation among others independent from quartz. Amorphous materials exhibited a variability different from quartz or feldspars. High ash content was associated with high feldspars or amorphous. Comparing these mineral compositions with those of aeolian dust deposited in this area and the local riverbed materials, we judged that the inorganic fraction could be explained by mixtures of aeolian dust and two kinds (crystalline and amorphous) of local volcanic materials.

The average Asian dust content in the peat was estimated 89.7 mg/g dry peat, using ash contents and contribution of aeolian dust endmember calculated from XRD analysis. Assuming the bottom of peat sequence was 7500 yrs BP (Takahashi and Igarashi, 1985) and the dry bulk density of peat was 0.1 g/cm^3 , the average Asian dust flux to the site was calculated as 0.14 $mg/cm^2/yr$, which was consistent with known values (0.2 - 4.5 $mg/cm^2/yr$) from previous studies around Japan. Temporal variation of the reconstructed dust flux generally showed an anti-phase relationship with the dust flux reconstructed in the Jeju Island (Li and Matsumoto, 2007). This might be due to the change in the meandering pattern of the westerly jet which promoted an alternation of the main dust transport pathway between northern and southern routes.

Keywords: aeolian dust, peat, Holocene, Mt. Daisetsuzan

Event sediments in Lake Inawashiro, Fukushima, Japan

*Yoshio Inouchi[1]

1. Faculty of Human Sciences, Waseda University

Varve-like sediments with a few millimeter thick are widely developed in the lake bottom of Inawashiro, central part of Fukushima prefecture. Several kinds of event sediments are intercalated in that sediment. The first one is tephra seams, Aira Tn tephra and Numazawa-Lake Numazawa tepha are famous examples. The second one is turbidite sediments caused by quakes of large earthquake, for example, 2011 earthquake off the Pacific coast of Tohoku and Great Kanto earthquake. The third one is dark brownish silty clay with some centimeters thickness underlain by light grey silty clay sediment. The fourth one is relatively coarse sediment with no characteristics in color. This study aims to clarify sedimentation mechanism of the third event layers which show reverse grading at lower part and normal grading at upper part. Sediments are sieved with metallic fine filter and composition of grains were examined. The result shows that light greyish part is mainly composed of quartz, feldspar and volcanic glass shards. And dark brownish part is composed mainly of siderites in adition to quartz, feldspar and volcanic glass shards. Dark parts in soft X-ray photo correspond to dark brownish part which contains siderite grains. Sedimentation model for this fourth event sediment is considered as follows. There was a small lake with sediment of several tens of meters to the northwest of Mt. Adatara. The sediment in the lake was composed chiefly of volcanic materials with siderite grains. Drainage area of Lake Inawashiro is famous for its heavy snowfall, and during cold ages heavier snowfalls are expected. At these ages large volume of melt water could destruct the wall of the lake which lead drastic flooding into Lake Inawashiro.

Keywords: Lake Inawashiro, event sediment, Flood

Preliminary reconstruction of Lake-level changes based on fossil diatom assemblages in Lake Biwa

*Takashi Suzuki[1], Yoshio Inouchi[2], Keisuke Otsuka[1]

1. Graduate School of Human Science, Waseda University, 2. Faculty of Human Sciences, Waseda University

This is a preliminary report of a research for reconstruction of lake-level change history of Lake Biwa based on the transfer function of diatom assemblage into water depth of surface sediment. We investigated diatom assemblages in drilling core sample from the lake bottom and surface sediment samples from the lake bottom from 5 m to 30 m in depth off estuary of Echi River, Lake Biwa.
Rate of planktonic species and water depth can be changed into the transfer function. The transfer function applied to drilled sediment from Lake Biwa into lake-level change history.The result shows that lake-level changes in Lake Biwa reflects climate changes. Before 1.5 ka, water depth rose under relatively cold conditions. During the last 1.5 ka, water depth rose under relatively warm conditions. The difference of response to climate condition suggests that snowfall in winter depending on East Asian winter monsoon and rainfall in summer depending on East Asian summer monsoon influence water balance of Lake Biwa.

Keywords: Lake Biwa, off estuary of Echi River, drilling core, planktonic diatom, transfer function, lake-level change

Extraction of paleoclimatic signal from the Eocene Green River Formation Lake Sediments in Utah, USA

*Ryusei Kuma[1], Hitoshi Hasegawa[1], Koshi Yamamoto[1], Jessica Whiteside[2], Masayuki Ikeda[3]

1. Nagoya University, 2. Southampton University, 3. Shizuoka University

EECO (Early Eocene Climatic Optimum) is known as the warmest period in the Cenozoic era. The Eocene Green River Formation, distributed at Utah, Colorado and Wyoming in US. consists of lake sediments in foreland basin of the Rocky Mountain. Most study about Green River Formation focused on oil shale with petroleum geology and organic geochemistry, However, there are only few sedimentological and inorganic geochemical works for reconstruction of paleoenvironment from the Green River Formation. Here we tried to reconstruct climate change during the EECO from the Green river Formation at the Uintah basin, based on the sedimentary analysis and geochemical analysis.
The Green River Formation is divided into 6 lake stages; fresh lake, transitional lake, highly fluctuating lake, rising lake, high lake and closing lake (Milkeviciene and Sarg, 2012). We investigated sedimentary facies at the Indian Canyon section, Utah, and recognized 3 –5 lake stages resulted from facies analysis. High lake stage, called Mahogany zone, was suggested as the peak of EECO. Furthermore, we established depth ranks by lithofacies and development of lamination to estimate detailed changes in paleo-lake levels. We also examined XRF and elemental analyzer measuring CNS to examine the inorganic and organic geochemical analysis, respectively.
Stable Ti/Al variation implies the changes in provenance would be negligible. The fluctuations of Ca/Al and Mn/Al are similar to that of depth rank record. K/Al shows high value at the high lake interval (Mahogany zone), implying enhanced chemical weathering intensity. Additionally, high TOC and low C/N in the Mahogany zone suggest the increased algae productivity in this zone. Our results suggest that the development of warm and humid environment in the middle-latitude North America at the EECO. We will analyze drilling core sample of Green River Formation with high-resolution.

Winter monsoon intensification during the last geomagnetic reversal in the Chinese Loess Plateau

*Yusuke Ueno[1], Masayuki Hyodo[2], Tianshui Yang[3], Shigehiro Katoh[4]

1. Department of planetology, Kobe University, 2. Research Center for Inland Seas, Kobe University, 3. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, 4. Museum of Nature and Human Activities, Hyogo

A link between geomagnetic field and climate is an unresolved long life research subject. Correlation between galactic cosmic rays (GCR) flux and low cloud cover can provide a theoretical rationale to this subject. Namely, the geomagnetic field intensity can change low cloud cover through GCR, and finally change the climate. The East Asian Monsoon (EAM) system significantly affects the climate in East Asia, including Japan. In order to clarify whether the EAM was influenced by geomagnetic field changes in the past, we analyzed loess paleosol deposits of the Chinese Loess Plateau (CLP) for the Marine Isotope Stage (MIS) 19 interglacial, during which the Matuyama-Brunhes magnetic polarity transition (MBT) accompanying a large field intensity decrease occurred.
For Chinese loess-paleosol deposits, magnetic susceptibility and frequency dependence are regarded as proxies of summer monsoon (SM) intensity, and grain size as a proxy of winter monsoon (WM) intensity. We collected samples from sections of about 7 m thick in Xifeng and 8 m thick in Lingtai, about 100 km south of Xifeng, in the CLP. Magnetic and grain size analyses were conducted at about 2.5~20-cm depth intervals. In both sites, the high-resolution paleomagnetic data reveal the detailed MBT with multiple polarity swings.
The SM and WM proxy curves, obtained from magnetic susceptibility and grain size data, show consistent variations well correlated the precessional sea level changes. The correlation shows that our data have an average resolution of about 120 yr. The SM intensity increases and WM intensity decreases during the MISs 19.3 and 19.1 seal-level highstands, and the opposite changes occur during the MIS 19.2 lowstand. This variation pattern is the same with the results of a number of previous studies. However, our high-resolution data reveal that the WM briefly strengthens around highstand MIS 19.3 which should be warm. The WM strengthening interval is partly overlapped with the MBT. According to the paleomagnetic intensity stack for the last 800 kyr (S-int 800), the WM strengthened when the geomagnetic field intensity decreased below one third of the present intensity, and also when the GCR flux increased to above 1.4 times, and about 2 times at maximum. The temporary WM strengthening occurred around highstand MIS 19.3 may be related to the climatic cooling observed in Osaka Bay, Lake Baikal, Israel, and Italy, probably caused by an increase in GCR due to the significant geomagnetic field decrease.

Keywords: Winter monsoon , Matuyama-Bryunhes boundary, Chinese Loess Plateau

Reconstruction of sea surface temperature over 50 years using coral Sr/Ca ratios from Seribu Island, Indonesia

*Ai Genda[1], Atsushi Suzuki[2], Mayuri Inoue[1]

1. Graduate School of National Science and Technology, Okayama University, 2. Geological Survey of Japan National Institute of Advanced Industrial Science and Technology (AIST)

The Indonesia archipelago is located between the Pacific and the Indian Ocean where is important place for the study of climate changes related to El Niño/Southern Oscillation (ENSO), Asian monsoon and/or Indian Ocean Dipole. However, instrumental and observed records such as water temperature and salinity has not been reported enough to understand climate systems around the Indonesian seas. Then, in this study, we have reconstructed sea surface temperature (SST) for more than 50 years from Sr/Ca ratios in a coral core collected from Seribu Island, Indonesia. Measurements of Sr/Ca ratios were performed by ICP-OES with monthly resolution and precision (RSD) was better than 0.3%. Based on the temperature records reconstructed by coral Sr/Ca ratios and time-series analysis, relationship between SST and climate events around Indonesian seas will be discussed.

Holocene environmental change of coastal lagoon inferred from diatom assemblage in Lake Hwajinpo, Korea

*Cho Ara[1], Deakyo Cheong[3], JinCheul Kim[2], DongYoon Yang[2], JinYoung Lee[2], Kaoru Kashima[1], Kota Katsuki[4]

1. Kyushu University, 2. Korea Institute of Geoscience and Mineral Resources, 3. Kangwon National University, 4. Shimane University

Hwajinpo is the largest lagoon in Korea, and its bottom sediment preserves good the Holocene records. To reconstruct the evolution of the Hwajinpo inner lake, analysis of AMS radiocarbon dating, OSL dating, grain size, and diatom assemblage were performed to the 11 m core obtained from the small river mouth of the inner lake (HJ02). According to diatom assemblage and grain size analysis, the environments were divided into 6 periods, labeled unit 1 to 6. The Hwajinpo lagoon was an estuarine environment which was influenced by marine water about 8 ka (Unit 1). Unit 2 is dominated by bay indicator species, meaning that the estuary changed to open bay condition which is connected to ocean. After then, marine species gradually decreased and the open bay changed to semi-closed bay as developed the sand bar. In case of Unit 4, marine species didn’ t occur because sand barrier is completely developed and there was a hiatus between 5.5 and 1.7 ka in about 7m depth because of flooding and delta switching event. Then, the environment of this site changed to an Oligohaline lagoon (Unit5) because of climate change especially precipitation increase. Since 1ka, the environment changed to like modern lagoon condition based on diatom assemblage which has been similar to modern assemblages.

Keywords: lagoon, diatom , paleoenvironmental change

Timing and characteristics of eolian-sand turbidites collected from the northeastern Arabian Sea

*Masafumi MURAYAMA[1,3], Kodai YAMASHITA[2], Yuhji YAMAMOTO[3], Tomohisa Irino[4]

1. Faculty of Agriculture and Marine Science, Kochi University, 2. Graduate School of Integrated Arts and Sciences, Kochi University, 3. Center for Advanced Marine Core Research, Kochi University, 4. Faculty of Environmental Earth Science, Hokkaido University

The relationship of sea-level changes and climatic changes in late Quaternary with turbidite deposition is reported. We found two ungraded and massive sand layers which were intercalated in calcareous clay in a sediment core (ER-4; W.D. 3,550 m) collected from the northeastern Arabian Sea. The characteristics of these contained dominantly the gray colored, pellet shaped marble grains which were consist of well-sorted and well-rounded of fine to medium sands. According to these features, these sand layers could be described as redistributed eolian sand, so-called “eolian-sand turbidites” (Sarnthein and Diester-Haass, 1977), derived from Thar Desert. The timing of these turbidite occurrences were determined after Heinrich event 5 and L.G.M., respectively, in response to major glacial to interglacial sea-level shifts and variability in the NE-Indian monsoon climate change. Thus, the frequency of eolian-sand turbidites must be influenced by sea-level variations, by cyclic processes of climatic origin and by variations in the subbottom morphology.

Keywords: eolian-sand turbidite, northeastern Arabian Sea, sea-level change, marine core

Sea surface environmental changes during the early to middle Miocene in the Indian, Atlantic and eastern equatorial Pacific Oceans based calcareous nannofossil assemblages

*Kotaro Ide[1], Koji Kameo[1]

1. Dept. of Earth Sciences, Chiba Univ.

During the early–middle Miocene, global ice volume was smaller than today and seawater temperatures in the oceans were likely higher until the Middle Miocene Climatic Optimum (MMCO: approximately 17 to 15 Ma). After the MMCO, global cooling had developed due to strong glaciation of the Antarctica and enhanced thermohaline circulation associated with deep water cooling (Shevenell et al., 2008; Billups and Schrag, 2002). This study investigates calcareous nannofossil assemblages of ODP cores in the southern Atlantic, Indian, and eastern equatorial Pacific Oceans in order to clarify sea surface environments during the early–middle Miocene. Calcareous nannofossil zones from CN1 to CN5a (Okada and Bukry, 1980) were identified in the investigated ODP cores and corresponding numerical ages are approximately 23 to 12 Ma. *Cyclicargolithus*, *Discoaster* and *Reticulofenestra* specimens dominantly occurred throughout the cores. Generally, an inverse relationship of relative abundances between *Discoaster* and *Reticlofenestra* seems to be observed. *Reticulofenestra* dominated assemblages imply that turbulent conditions of sea surface waters with rich nutrients occurred and they correspond to the time during low $\delta^{18}O$ conditions. Conversely, abundant occurrences of *Discoaster* indicate that well-stratified sea surface waters with poor nutrients developed in the time of high $\delta^{18}O$ values (Sato and Chiyonobu, 2009). In the examined sites, abundant occurrences of *Reticulofenestra* with fewer *Discoaster* specimens were found in approximately 21 and 15 Ma and they correspond to the beginning of the glacial periods Mi-1a and of Mi-2 (Billups et al., 2002), respectively. It suggests that these variations had mainly been controlled by cyclic developments of the Antarctic ice sheets. Moreover, calcareous nannofossil floras in each ocean were influenced and modified by local environmental changes, e.g. upwelling in the equatorial regions and/or western margin of Indian Ocean.

References

Billups, K., Channell, J. E. T., and Zachos, J., 2002. *Paleoceanography,* **17**(1).
Billups, K., and Schrag, D. P., 2002. *Paleoceanography*, **17**(1).
Okada, H. and Bukry, D., 1980. *Marine Micropaleontology*, **5**, 321–325.
Sato, T. and Chiyonobu, S., 2009. *Fossils*, **86**, 12–19.
Shevenell, A. E., Kennett, J. P. and Lea, D. W., 2008. *Geochemistry, Geophysics, Geosystems*, **9**, Q02006.
Zachos, J., Pagani, M., Sloan, L., Thomas, E. and Billups, K., 2001. *Science*, **292**, 686–693.

Keywords: Calcareous nannofossils, Miocene, Upwelling, Stratification, ODP

The variation in mineral fraction corresponding to Iceberg collapse obtained by X ray powdered diffraction method at MIS104

*Masato Makio[1], Masahiko Sato[2], Tatsuya Hayashi[3], Masao Ohno[4], Yoshihiro Kuwahara[4]

1. Graduate School of Integrated Sciences for Global Society, Kyushu University, 2. National Institute of Advanced Industrial Science and Technology, 3. Mifune Dinosaur Museum, 4. Division of Earth Sciences Faculty of Social and Cultural Studies

The climate change in the period that the ice sheets appeared and then developed in the northern hemisphere was unknown in many respects. However, the development and collapse of the continental ice sheets are considered to be closely related to climate change. We have researched that how the relationship of ice sheet collapse and deep water circulation at thousands of years scale varied with the development of the ice sheet by comparing ice rifted debris (IRD) count and rock magnetic records in the marine sediment core drilled in the North Atlantic Ocean. The records in the sediment core around marine isotope stage (MIS) 100 in which the continental ice sheet is considered to have greatly developed have been reported (Ohno et al, 2016).
In our earlier study, IRD count and rock magnetic analysis in MIS 104 (2.58 - 2.62 Ma) before MIS100 have been reported (Makio et al., JpGU 2015), but minerals constituting the sediments in MIS 104 have not been mentioned. Minerals in the sediment provide us useful information such as the origin of continental ice sheets and the carbonates constituting marine plankton shells. Therefore, we estimated the relative amount and/or the weight ratio of minerals in the sediment samples by the X-ray diffraction (XRD) decomposition method.
The samples used in this study are in a sediment core drilled at Integrated Ocean Drilling Program (IODP) Site U1314 off southern Iceland. This sea area is a flow channel of the North Atlantic Deep water formed in the northern part of Iceland, and the deep water transports basaltic clusters around Iceland. The sediment samples corresponding to around MIS 104 (2.58 - 2.62 Ma) were collected at intervals of about 4 cm (about 200 - 400 years) . For XRD measurements, a standard sample, zincite (ZnO), was added in a fixed percentage (5 wt%) to the sediment sample, and then they were mixed and homogenized with an agate mortar . XRD measurements were performed by the step scan method using a RIGAKU X-ray Diffractometer RINT 2100V. The XRD data obtained were decomposed into each component (intensity (area) of each elementary peak) by the XRD decomposition method (profile fitting method) using the program software MacDiff (Petschick, 2000).
The relative fluctuation records of each mineral were reconstructed during MIS 104. Especially, minerals which are suggestive of continental origin, such as quartz, mica, feldspar, showed a sharp increase at the term of the IRD events. On the other hand, calcite gradually increased and decreased over the glacial - interglacial period. The results obtained in this experiment supported the results of IRD count and rock magnetic measurements in MIS104 in our previous study.

Keywords: Ice Rafted Debris, Rock magnetism, X ray powdered diffraction method

Variations in paleovegetation recorded by terrestrial plant biomarkers in the sediments from IODP Site U1385 off the SW Iberian Peninsula

*Saki Yano[1], Satoshi Furota[1], Ken Sawada[1]

1. Faculty of Science Hokkaido University

Terrestrial plant-derived biomarkers such as long chain *n*-alkane, fatty acid and alcohol are prevalent in marine sediments, and are used as diagnostic tools for reconstructing terrestrial input, paleovegetation and atmospheric conditions. Plant terpenoids, another class of higher plant biomarkers, also occur in various types of marine sediments. Chemotaxonomic feature of plant terpenoids has been emphasized by dataset of recent plant natural product as well as geochemical analysis of geological samples (e.g. peat, plant fossils and coals). Hence, compositions of plant terpenoids in marine sediments may reflect paleo vegetation and climate condition. However, occurrence and composition of these plant terpenoids in marine sediments are hardly known. In the present study, we analyzed the terrestrial plant-derived biomarkers in the sediment core recovered by IODP exp. 339 Site U1385 to reconstruct past variation of flux and composition of the plant terpenoids.

We used sediments samples from in the northeastern Atlantic off the SW Iberian Peninsula (IODP site U1385), so-called ‘Shackleton Site’. The age ranges between Marine Isotope Stage (MIS) 12 and MIS 10 are analyzed, and especially, the paleoclimatic reconstruction of the MIS 11 is focused. Several studies have been examined the climatic variations of MIS 11 by a high-resolution direct land-ocean comparison from the Site U1385 (e.g. Oliveira et al., 2016, *Quat. Res.*). Lipids were extracted with dichloromethane / methanol, and separated to aliphatic, aromatic and polar fractions. Lipids were identified and quantified by GC/MS. In addition to the plant biomarker analyses, we estimated the paleotemperatures of sea surface layer using alkenone unsaturation index (UK'_{37}).

Diterpenoids such as dehydroabietic acid (gymnosperm origin) as well as triterpenoid such as β-amyrin, friedeline and lupeol (angiosperm origin) have been mainly identified as the plant terpenoids in almost samples. The dehydroabietic acids / β-amyrin ratios, which are representative of gymnosperm / angiosperm ratios, tend to decrease during the interglacial period of MIS 11. The dehydroabietic acid is typical biomarker as conifer woods. Thus, the decreasing of the relative abundances of the dehydroabietic acid in marine sediments during MIS 11 is assumed to decline the coniferous vegetation in hinterland areas around the Site U1385. The variations in the other gymnosperm / angiosperm ratios such as total diterpenoids / triterpenoids ratios are similar trends during MIS 12 –MIS 11. On the other hand, the lupeol / β-amyrin and lupeol / total triterpenoids ratios are lower during glacial periods including MIS 12 and MIS 10, but tend to increase during interglacial period MIS 11. The lupeol is known to be originated from various angiosperms, especially legume and aster families including lupines. The variations in lupeol ratios are concordant with those in $\delta^{18}O$ values, alkenone-based temperatures, and pollen percentages of the Mediterranean forest species in the Site U1385 (Oliveira et al., 2016). Interestingly, increasing spikes are observed in the lupeol ratios during the cooling stages in MIS 11 (ca. 390 ka), and well correlated to the minimal values of the Mediterranean forest. Thus, the lupeol ratios can be an indicator of cooler vegetation. From these results, the indices using the plant terpenoids in marine sediments have potentials for reconstructing paleoclimatic variations via paleovegetation changes at the glacial/interglacial cycling during the Quaternary.

Keywords: paleovegetation, biomarker, plant terpenoid, MIS 11, northeastern Atlantic Ocean

Sea-surface temperature chanhes in the Japan Sea off Wakasa since the Last Glacial Maximum based on silicoflagellete assemblages

Kyohei Tanizaki[1], *Yusuke Okazaki[1], Takuya Sagawa[2], Jonaotaro Onodera[3]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Faculty of Natural System, Institute of Science and Engineering, Kanazawa University, 3. Japan Agency for Marine-Earth Science and Technology

The Japan Sea is a marginal sea, connecting to the East China Sea, the North Pacific and the Okhotsk Sea through the Tsushima, Tsugaru, Soya, and Mamiya straits. During the Last Glacial Maximum, the connections between Japan Sea and the circumjacent seas were highly limited due to sea-level drop down to ~130 m. Because of significant decrease in the Tsushima Warm Current (TWC) inflow into the Japan Sea, sea-surface temperature (SST) of the glacial Japan Sea must have been chilled. However, no previous study was unable to constrain glacial sea-surface temperature of the Japan Sea caused by low salinity surface water and semi-closed environments. For instance, oxygen isotopes of planktic foraminiferal shells showed significantly light values highly influenced by the glacial low salinity. Alkenone paleo-thermometry did not work well due to low salinity, indicating unusually high SST during LGM. Silicoflagellate is a marine phytoplankton with biogenic opal skeletons. Most of the modern silicoflagellates are belonging to two genera: *Dictyocha* mainly distributing tropical to temperate regions and *Stephanocha* mainly distributing polar to subpolar regions. In addition, silicoflagellates can survive in brackish water. Therefore, silicoflagellates has a great potential to reconstruct glacial SST in the Japan Sea. Here we present SST reconstruction in glacial Japan Sea based on silicoflagellate assemblage in Japan Sea sediment. The sediment core KR15-10 WB6 was collected off Wakasa at water depth 845 m. Age model of the piston core has been established based on radiocarbon datings on planktic foraminiferal shells. Based on modern analog technique of the silicoflagellate assemblages, quantitative SST reconstruction of SST was performed for the past 28.5 kyrs. Reconstructed SST of the glacial Japan Sea indicated 5 degree C or colder. Gradual SST increase was observed since 14 ka and reached 14 degree C (modern SST) at 11 ka. These suggest that resuming of TWC inflow into the Japan Sea occurred at ~14 ka. Since 11 ka, TWC strength would have been comparable to the present one.

Keywords: Japan Sea, Last Glacial Maximum, Sea-surface temperature, Silicoflagellate assemblage

Estimation of past intermediate water temperatures in the northwestern Pacific based on radiolarians: it’ s suitability and constrains

*Kenji Marc Raymond Matsuzaki[1], Takuya Itaki[2]

1. Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 2. Geological Survey of Japan, AIST, Marine Geology Research Group

The use of siliceous microfossil assemblages, such as radiolarians for reconstruct past sea water temperature were developed since decades but all the studies only deal with reconstruction of Sea Surface Temperatures (SST). The most known reconstructions are those of the CLIMAP project, reconstructing worldwide SST during the Marine Isotopic Stage (MIS) 2. In this project, SST of Southern Ocean and Pacific Ocean, were reconstructed by the use of diatoms and radiolarians applying a Q-mode factor analysis following the statistical procedure of Imbrie and Kipp (1971). Following this method, numerous studies reconstructed past SST in the Southern Ocean and Pacific Ocean. In the North Pacific, the vertical distributions of radiolarian species have been well investigated and we know that several species are living at the intermediate water depths (200- 1000 m). Therefore, the establishment of a new data-set composed of intermediate water depth living taxa would potentially enable for the first time the estimation of the paleo intermediate water temperature. In this study, we propose a new data-set of radiolarian assemblages from the surface sediment of the Northwestern Pacific for reconstruct past intermediate water temperature.

In this context, we analyzed 87 surface sediment samples covering the northwestern Pacific Ocean from 1˚ to 50˚N and 120˚ to 167˚E. Among, 77 samples were collected by the Geological Survey of Japan and 10 samples were collected by the Japan Agency for Marine-Earth Science. Changes in radiolarian assemblages have been analyzed on these samples. When we try to reconstruct temperature of the intermediate water based on microfossil assemblages, two major issues constrain the reconstruction. Because intermediate water species represent a much lower portion of the total assemblage, the variation of their relative abundances are less significant than those recorded in the surface and would cause some biases in the reconstruction. The second issue is that the intermediate water temperature changes greatly between 200 and 1000 m. This also create biases. For try to minimize the effect of such biases, we proposed a normalization of the data-set and tied our normalized assemblage to the temperature at water depth of ca. 500 m. This water depth has been chosen because of the relative stability of temperatures between 500-1000m, and most of our selected species cover the water depth of ca. 500 m. This enable us to estimate past intermediate water temperature at ca. 500 m within an error margin of 1.2 ℃ (R^2 =0.84), which is promising. However, some concerns remain, particularly for temperature higher than 9℃, but for temperature lower than 9℃, it seem that our method is relatively suitable (R^2=0.89).

Keywords: Northwest Pacific, Intermediate water temperature, Radiolarians

The undatables: Quantifying uncertainty in a highly expanded Late Glacial - Holocene sediment sequence recovered from the deepest Baltic Sea basin –IODP Site M0063

*Stephen Obrochta[1], Andrén Thomas[2], Szilárd Zsolt Fazekas[3], Bryan Lougheed[4], Ian Snowball[4], Yusuke Yokoyama[5], Miyairi Yosuke[5], Reisuke Kondo[6], Aarno Kotilainen[7], Outi Hyttinen[8], Annick Fehr[9]

1. Akita University, 2. Södertörn University, 3. Akita U., 4. Uppsala University, 5. Tokyo University, 6. Kogakkan University, 7. Geological Survey of Finland, 8. University of Helsinki, 9. Aachen University

Laminated, organic-rich silts and clays with high dissolved gas content characterize sediments at IODP Site M0063 in the Landsort Deep, which at 459 m is the deepest basin in the Baltic Sea. Cores recovered from Hole M0063A experienced significant expansion as gas was released during the recovery process, resulting in high sediment loss. Therefore during operations at subsequent holes, penetration was reduced to 2 m per 3.3 m core, permitting expansion into 1.3 m of initially empty liner. Fully filled liners were recovered from Holes B through E, indicating that the length of recovered intervals exceeded the penetrated distance by a factor of >1.5. A typical down-core logarithmic trend in gamma density profiles, with anomalously low density values within the upper ~1 m of each core, suggests that expansion primarily occurred in this upper interval. Thus, we suggest that a simple linear correction is inappropriate. This interpretation is supported by anisotropy of magnetic susceptibility data that indicate vertical stretching in the upper ~1.5 m of expanded cores. Based on the mean gamma density profiles of cores from Holes M0063C and D, we obtain an expansion function that is used to adjust the depth of each core to conform to its known penetration. The variance in these profiles allows for quantification of uncertainty in the adjusted depth scale. Using a number of bulk ^{14}C dates, we explore how the presence of multiple carbon source pathways leads to poorly constrained radiocarbon reservoir age variability that significantly affects age and sedimentation rate calculations.

Keywords: 14C, IODP, Age modeling, Sediment expansion, Paleomagnetics

Marine Isotope Stage 2 sea-level records deduced from sediment cores in the Bonaparte Gulf and glacial isostatic adjustment model

*Takeshige Ishiwa[1], Yusuke Yokoyama[1], Jun'ichi Okuno[2], Katsuto Uehara[3], Minoru Ikehara[4], Stephen Obrochta[5]

1. Atmosphere and Ocean Research Institute, the University of Tokyo, 2. National Institute of Polar Research, 3. Research Institute for Applied Mechanics, Kyushu University, 4. Center for Advanced Marine Core Research, Kochi University , 5. Akita University

Marine Isotope Stage 2 (MIS 2) is the latest glacial period (30,000–15,000 years ago), including the Last Glacial Maximum (LGM) characterized by the maximum of global ice volume. The comparison of various paleoclimatic records with sea-level change derives an understanding of the earth climate system. However, global sea-level change during MIS 2, especially the LGM, is less understood due to its paucity of data and its uncertainty. The Bonaparte Gulf, northwestern Australia, is a suitable region to reconstruct the global sea level change since the Gulf is far from the former ice sheet and tectonically stable. Here we present the new sea-level records from the Bonaparte Gulf and the revision of the global ice volume history during the MIS 2 using marine sediment cores, paleo-tidal model and glacial isostatic adjustment (GIA) model. To reconstruct relative sea level in the Bonaparte Gulf, we employed exceeding 250 radiocarbon dates of carbonates and bulk organic matters from cores with various depths, combined with the two-dimensional tidal model for the evaluation of paleo-tidal effects to the past sea level in the Bonaparte Gulf. We also propose the revised global ice volume history during the MIS 2 based on results from GIA model and the new relative sea-level records for the Bonaparte Gulf.

Keywords: Sea Level, GIA model, MIS2, radiocarbon dating

Scale and frequency of cooling-drought events by asteroid impact

*Kunio Kaiho[1], Naga Oshima[2]

1. Graduate School of Science, Tohoku University, 2. Meteorological Research Institute

Asteroid impacts to the Earth can form global stratospheric soot and sulfate aerosols sourced from target rocks leading to global decreases in sunlight, temperature, and precipitation. Scale of the cooling-drought events is decided by amount of those aerosols. Their amounts vary widely depending on impact location and impact energy. However, impact site variation has not considered for calculation of probability of the cooling-drought events by asteroid impacts. We analyzed climate changes by different size of asteroids hitting various impact locations. Here we show that significant cooling in high-middle latitudes with drought in low and high latitudes occur in frequency of once/7 million years, which decreases to one eighth of previous thought. The cooling-drought events by bolide impacts become more rare events for humans, but can occur during the duration of anthroposphere. Cooling in high-middle latitudes by >5 ˚C on land and drought in low latitudes damage vegetation and agriculture globally, which can induce a significant decrease of number of animals including humans. In order to avoid the disasters, an asteroid orbit should be controlled to hit to the oceans when impacts cannot be avoided, because of low amount of stratospheric aerosol sources inducing cooling in the ocean areas, and a little amount of stratospheric sulfate aerosol formed by impacts.

Keywords: climate change, asteroid impact

The response of the climate to changes in the orbital parameters

*Kanon Kino[1], Ayako Abe-Ouchi[1,2], Fuyuki SAITO[2], Ryouta O'ishi[1]

1. Atmosphere and Ocean Research Institute, the University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology

Whereas paleoclimatic records consist with Milankovitch theory (Hays et al., 1976), the response of the climate to changes in the orbital parameters (eccentricity, precession and obliquity) is poorly understood. Abe-Ouchi et al. (2013), using comprehensive climate and ice-sheet model (IcIES-MIROC), proposed that 100,000-year glacial cycles in last 400,000 years can be explained by the response of the climate to change in the insolation. It is a mystery that termination 1, the deglaciation from last glacial maximum (LGM; ~20,000 years ago) to present, and termination 5, the deglaciation from marine isotope stage (MIS) 12 to MIS11 (~400,000 years ago), were accompanied with climate changes as large as termination 2 in spiite of the fact that eccentricity was relatively small (relatively small summer insolation change) during termination 1 and 5, while it was large (large summer insolation change) during termination 2 (400,000 years problem). To consider this problem, we analyze the role of the orbital parameters for the climate changes during the terminations by examining the response of the climate to changes in the various orbital parameters. Here, using MIROC-LPJ (O'ishi and Abe-Ouchi, 2011), the sensitivity experiments combined various orbital parameters show that the changes in surface temperature are not always linear to the changes in insolation, furthermore, the large obliquity with winter solstice make the temperature higher than the small obliquity with summer solstice when eccentricity is relatively small. It suggests that the surface temperature during termination 5 with higher obliquity can be higher without increasing carbon dioxide contents, even if the insolation was weaker. In this presentation, we discuss these sensitivity experiments in detail. We will also examine the snapshot experiments in 2,000 years intervals with only changing orbital parameters during termination 1 and 5 by MIROC-LPJ.

Keywords: orbital parameter, glacial-interglacial, model

Impact of glacial ice sheets on the duration of the stadial climate: Role of surface wind and surface cooling

*Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1]

1. Atmosphere and Ocean Research Institue, University of Tokyo

It has been shown from ice core reconstructions that glacial periods experienced climate shifts between warm interstadials and cold stadials. The duration of these climate modes varied during glacial periods, and that both the interstadials and stadials were shorter during Marine Isotope Stage 3 (MIS3) compare to MIS5. Recent studies showed that the duration of the interstdials is controlled by the Antarctic temperate through its impact on the stability of the Atlantic Meridional Overturning Circulation (AMOC). However, similar relation could not be found for the stadials, suggesting that other climate factor (e.g. differences in ice sheet size, greenhouse gases and insolation) may play a role. Thus, for a better understanding of the stability of the climate, it is very important to evaluate the impact of these climate factors on the duration of the stadial climate. In this study, we investigate the role of glacial ice sheets. For this purpose, freshwater hosing experiments are conducted with an atmosphere-ocean general circulation model MIROC4m under several ice sheets configurations computed in an ice sheet model Icies (Abe-Ouchi et al. 2013). The impact of glacial ice sheets on the duration of the stadial climate is evaluated by comparing the behavior of the weak AMOC after the freshwater forcing is reduced. All experiments show a drastic weakening of the AMOC in response to the freshwater hosing, which accompanied a cooling over the North Atlantic, a southward shift of the tropical rain belt and a warming over the Antarctic. We find that experiments with smaller ice sheet takes more time to recover after the freshwater hosing is reduced. Sensitivity simulations show that differences in the surface wind is important in causing the shorter stadial under larger ice sheets, while differences in the surface cooling has an opposite effect. Thus our result suggests that differences in the surface wind induced by the ice sheets play an important role in causing shorter stadials during MIS3 compare to MIS5.

Keywords: AMOC, Stadial, Ice sheet

Numerical simulation about meandering Kuroshio in LGM

*Yoshimi Sugiyama[1], Minoru Ikehara[2], Hirohiko Nakamura[3]

1. Kochi University, Graduate School of Integrated Arts and Sciences, 2. Center for Advanced Marine Core Research, Kochi University, 3. Kagoshima University, Faculty of Fisheries, group of marine environment

The Kuroshio Current(KC) is the western boundary current of the North Pacific subtropical gyre. The KC has a role for transportation of heat energy to the subarctic zone from the tropical zone. The KC transports not only heat energy but also plankton, marine resources, and chemical substance, so the KC variation has a major influence on marine environment and climate change in the north Pacific region.
At present, the variation of past KC is mainly reconstructed by proxy analysis from marine core on paleoceanography (e.g., Ujiie and Ujiie [1999], Ujiie et al. [2003], and Kawahata et al. [2003]), but each study (proxy analysis) showed different interpretations about the main route of the KC during the Last Glacial Maximum (LGM) in the Okinawa Trough, and the physical oceanographic approach for the past KC variability is significantly limited.
The main purpose of this study is to reconstruct the main pass of KC in the last glacial using a 3-D ocean model with global sea level change. The numerical simulation with realistic topography was performed using the 2003 version of the Princeton Ocean Model [Blumberg and Mellor, 1987] configured for the western North Pacific Ocean, domain in 5˚N-55˚N and 120˚E-170˚E, and horizontal resolution of 1.3/10˚ - 3.9/10˚.
When the sea level drops at -120m for LGM, the KC passes through the Okinawa Trough, which is almost same route of modern KC. In addition, when the sea level is down, warm- and cold-core eddies tend to form frequency and become large scale in the Sikoku Basin, and the main route of the KC shows a large meander path. These results suggest that the KC became easily large meandering during the LGM because strengthen topographic closed around the Sikoku Basin by sea level drop.

Keywords: Kuroshio, Paleoceanography , Paleoclimatology

Silicoflagellates assemblages on the Danjyo Basin in the East China Sea since the last glacial maximum

*fumiaki nishizono[1], Yusuke Okazaki[1]

1. Department of Earth and Planetary Sciences, School of Science, Kyushu University

The East China Sea (ECS) is a marginal sea of the western North Pacific. ECS is divided into two areas of different water depth character: continental shelves shallower than 200 m in the northeast, which occupies greater than 70% of ECS and deep basin down to >2000 m in the south east (Okinawa Trough). Warmer and more saline Kuroshio Water and cooler and less saline Chinese Coastal Water influence on surface conditions of the ECS. Silicoflagellates are unicellular marine plankton and they have simple geometric siliceous skeletons which are constructed of hollow, tubular rods. There are two major silicoflagellate genera *Dictyocha* and *Stephanocha* dwell mainly tropical to subtropical region and polar to subpolar region, respectively. Hence, ratio of two genera in sediment is a qualitative proxy of sea-surface temperature. Here we present a silicoflagellate assemblage in sediment core sample on the Danjo Basin of ECS sediment to reconstruct sea-surface temperature change since the last glacial maximum. Piston core KY07-04-01 (31˚38.35’ N, 128˚56.64’ E, 758 m) was recovered from the northern edge of Okinawa Trough. Age model of KY07-04-01 was established based on thirteen ^{14}C ages and one tephra layer, K-Ah tephra (Kubota et al., 2010). In this study, silicoflagellate assemblages of KY07-04-01 were investigated by using light microscope (LM). A total of 11 silicoflagellate species were encountered during the microscopic observation. Change in the ratio of the *Dictyocha/Stephanocha* genus of this region showed a tendency to increase for the past 18 kyrs, suggesting intensified Kuroshio Water inflow. The supporting evidence is came from *Dictyocha epiodon*, currently abundant in the Kuroshio Extension and the Gulf of Alaska, showed gradual increase from the last glacial maximum (LGM) to the late Holocene. *Stephanocha speculum* is the representative species in subarctic and polar region. Relative abundances of S. speculum were high during LGM. This indicates colder and less saline surface water was covered on the Danjo Basin. However, constant occurrence of *Dictyocha messanensis*, which widely distributes from tropical to temperate region, shows that Kuroshio Water has been flowed into the ECS even during LGM.

Keywords: silicofagellate, East China Sea, Danjyo Basin, sea-surface temperature

Geological Characteristics in shallow marine around Miyako-jima Island based on Sub-bottom profiles and bathymetric data

*Takahiko Inoue[1], Kohsaku Arai[1], Masahiko Sato[1], Ayanori Misawa[1], Takuya Itaki[1]

1. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology

National Institute of Advanced Industrial Science and Technology (AIST) carried out the marine geological survey around the Miyako-jima Island, Okinwa in 2016 using R/V Hakurei belonged to JOGMEC. We obtained the high-resolution data by Sub-Bottom Profiler (SBP) survey and Multi-Beam Echo Sounder (MBES) bathymetric survey. This presentation shows the geological characteristics in shallow area around the Miyako-jima Island based on SBP profiles and MBES bathymetric data.
Flat sea bottom shallower than 200 meters in depth widely spreads around the Miyako-jima and the coral reefs have developed in nearshore area. In this area, high-resolution profiles depicting surface geological structure under sea bottom were obtained by SBP. Sediment under sea bottom is divided into two units. Remarkable unconformity is recognized between upper stratified sedimentary unit and lower unit showing poor internal reflectors. Remarkable unconformity exposed from in the shallow area is indicating remarkable mound topography. Height of the mounds of remarkable unconformity is reaching to 8 meters from sea bottom. The projects are recognized only in shallow marine area than 100 meters in depth. Therefor we presume that these projects are submerged coral reefs developed accompanied by sea level rise since last glacial maximum.

Keywords: Sub-Bottom Profiler , Multi-Beam Echo Sounder bathymetric survey , Miyako-jima Island , coral reef, surface marine geology, shallow sea

High-resolution seismic reflection and SBP surveys on the Miyako-Sone platform, Ryukyu Island Arc, northwestern Pacific

*Kohsaku Arai[1], Takahiko Inoue[1], Ayanori Misawa[1], Shin-ichiro Yokoyama[1]

1. Institute of Geology and Geoinformation, National Institute of Advanced Industrial and Technology

Shallow seismic profiling using AA300 Boomer system with 24 channels digital streamer cable and parametric SBP (sub bottom profiler) surveys were conducted on the Miyako-Sone platform, northeast of Miyako-jima, Ryukyu Islands, northwestern Pacific Ocean. Study area is reported that existence of the drowned reef probably formed during the final stage of the cooler postglacial period (Arai et al., 2016). High-resolution seismic profiles show a distinct, irregularly-undulated reflector which form the topographic high surround shallowest area, but have internally chaotic reflections. In the other hand, the parallel stratified sediment of less than 20 m (25 ms two-way travel time: calculate thickness using velocity is about 1500 m/s) covers the unconformable erosional surface which is characterized by distinct flat reflector 90-120 m (120-160 ms two-way travel time) in depth. Some small mounds, which are outlined by strong reflections are found above the distinct flat reflector. The feature of this reflector suggests that it represents an erosional surface formed during last glacial maximum. We conclude that the mound shape structures are submerged coral reefs, and reefal deposits, that developed following the last glacial maximum. Such high-resolution seismic profiles may be useful and effective indicator of the detailed paleoenvironment.

Keywords: Ryukyu Arc, marine geology, seismic reflection survey, Quaternary

