Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

BPO02-01 Room:105 Time:May 21 09:00-09:30

Calcification mechanisms in foraminifera and proxy incorporation

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Calcifying organisms, such as pteropods, bivalves, corals and foraminifera provide a rich resource for pale-oceanographers and ?climatologists because their geochemical make-up (proxies) can be used to reconstruct past ocean history and evolution during and after natural carbon perturbations. However, it has been shown for all geochemical proxies that the main assumption of only one environmental variable controlling a target proxy is too simple. Empirical calibrations introduce a lot of uncertainty because the mechanisms of proxy incorporation are not well understood. The major problem is that the calcification mechanisms are still a black box. In this presentation I will review our current understanding of calcification and proxy incorporation in foraminifera.

Keywords: calcification, foraminifera

Japan Geoscience Union Meeting 2013
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BPO02-02 Room:105 Time:May 21 09:30-09:45

Environmental variation during foraminiferal calcification

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Foraminifera have been considered as one of the major carbonate producer in ocean. Their calcareous tests are broadly utilized as paleo-environmental indicators in various studies of earth science because their tests have been archived as numerous fossil in sediment for long time and various environmental information are brought by population, morphology and geochemical fingerprints. The knowledge about the cytological process on carbonate precipitation has been described for couples of decade using by OM, SEM and TEM. Foraminiferal calcium and carbonate ion managements are of great interest for broad field of biogeosciences. Our studies showed the potential to understanding the biomineralization of foraminifera by the application of fluorescent indicators. Recently, we visualize the spatial distributions of cytological calcium and pH in living cell at same time. Observed results show that foraminifera controls very detailed timing of pH variation and concentration of calcium at any stage of chamber formation dynamically. These observations results will help to consider how the geochemical proxy on the foraminiferal test working as paleo environmental indicators.

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BPO02-03 Room:105 Time:May 21 09:45-10:00

Distribution of intracellular pH and algal endosymbionts during chamber formation in symbiont-bearing reef foraminifers

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Calcification mechanisms of algal symbiont-bearing reef foraminifers have not yet been well understood. In particular, it is cytologically not clear how the photosynthesis by algal endosymbionts enhance the calcification of host foraminifers. We visualized the distribution of intercellular pH and algal endosymbionts using a fluorescence probe HPTS as well as chlorophyll autofluorescence. High pH vesicles were gradually stored around symbionts before chamber formation. Our observations suggest that the photosynthesis by symbionts enhances the production of calcite needles or carbonate pools in vesicles by removing CO2 around them.

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BPO02-04 Room:105 Time:May 21 10:00-10:15

Autoclave aquaria allow for high-pressure culture experiments on deep-sea benthic foraminifera

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Our understanding of palaeodeep-water circulation modes and deep-water renewal in the world's oceans is essentially based on isotopical and geochemical ratios recorded in tests of calcareous deep-water benthic foraminifera that precipitate their shells in a constant ratio to the surrounding water mass. However, as more field data are assembled it appears that the documentation of deep-water in benthic foraminiferal shells is not always straightforward. Therefore, culture experiments on deep-sea benthic foraminifera are needed to verify the established palaeodeep-water proxies. However, to our knowledge, barophilic species like F. wuellerstorfi, the most trusted species for reconstructions of palaeodeep-water circulation and ventilation, neither formed new chambers nor reproduced in mesocosms kept at 1 bar. To accommodate this problem we have developed facilities and procedures that allow long-lasting high-pressure culture experiments on undepressurized deep-sea sediments and associated fauna and flora. In this presentation I will describe the experimental set-up and present results from methane-seepage simulations.

Keywords: pressure, culture, foraminifera

Japan Geoscience Union Meeting 2013
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BPO02-05 Room:105 Time:May 21 10:15-10:30

Laboratory culture experiments: effect of dissolved oxygen concentration on planktonic foraminifera

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Planktonic foraminifera shows significant species turnover ratio related Cretaceous oceanic anoxic event (OAEs), however, the direct effect of dissolved oxygen (DO) concentration on planktonic foraminifera remain obscure. Although culture experiments can investigate quantitatively the relationship between foraminiferal ecology and environmental parameters, DO-controlling experiment has never been conducted because of the difficulty of observation and/or control of dissolved oxygen under the modern ocean condition. In the present study, we cultured two planktonic foraminifera species (*Orbulina universa* and *Globigerina bulloides*) under six different DO conditions. Both species have extremely high tolerance to low DO than we expected before, and it suggests that at least ”dysoxic” condition (more than 0.7 mg O_2 l^{-1}) could not be a direct cause of the extinction of planktonic foraminifera at OAEs. Their high tolerance to extremely low DO would be caused by the evolutionary descendant of benthic foraminifera. Final shell weight increased with DO despite almost the same culture duration among treatments, thus it suggests foraminiferal fossil shell weight could reflect the DO conditions.

Keywords: planktonic foraminifer, culture experiment, dissolved oxygen concentration

Japan Geoscience Union Meeting 2013
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BPO02-06 Room:105 Time:May 21 10:30-10:45

Subarctic and Arctic Emiliania huxleyi coccolith morphological responses to the growth temperatures

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Coccolithophore is a key calcified phytoplankton for biogeoscience because of their specific products such as calcified scales, coccolith, and unsaturated ketones, alkenone. As a biomaker, the chemical compositions of alkenones are often used to estimate paleo ocean temperatures and to identify the changes of the marine environments (e.g., Harada et al., 2012). In particular, the polar region is an important area to recognize the changes of the global environments and the sea-ice melting is known to be accelerated by the global warming. MIRAI subarctic expeditions have been continued to investigate the subarctic to Arctic environment and concurrently the culture experiments of marine organisms including coccolithophores have been performed to predict the future changes of marine ecosystem. In this study, two Emiliania huxleyi strains, MR57N and MR70N, isolated by MIRAI subarctic expedition in 2010 were cultured at the different temperatures (5, 10, 15 and 20?C) and salinities (25, 32, and 35 per mill) and investigated from the viewpoint of the coccolith morphology. As the results, these strains showed the similar growth properties that the growth rate increased with raising the temperature. According to SEM observations and the image analyses, the size (length of distal shield: LDS) and the numbers of distal shield elements of the coccolith decreased with raising the temperature. The central area of the coccoliths was also changed from grill structures to completely calcified structures. Moreover, the cell size of E. huxleyi decreased with raising the temperature. Thus, the subarctic and Arctic E. huxleyi stains showed the correlations between cell sizes and coccolith morphometic parameters with variable central area morphology depending on the growth temperatures. For the salinity experiments, there is almost no variation on the growth properties and a little variation on the morphometrical parameters. These results imply that the subarctic and arctic E. huxleyi strains can maintain enough to grow in the temperature range between 5 to 20?C and the salinity range between 25 to 35 per mill, suggesting that these strains can ideally survive under the warmer and/or the less salinity environments. The coccolith morphologies and the parameters vary in response to the growth temperature but not to the salinity. This relationship was applied to the natural plankton samples reported by Bollmann et al. (2009) and the part of their data was correlated with sea water temperatures but the data shallower than 15 m depth was not. This may imply the importance of the light intensity and the further culture experiments with the different light intensity are required.

Harada et al. (2012) Global Biogeochemical Cycles 26, GB2036.
Bollmann et al. (2009) EPSL 284, 320.

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BPO02-07 Room:105 Time:May 21 11:00-11:15

Morphological and ecological characters of two cryptic genetic types in the radiolarian *Spongotrochus glacialis*.

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The discovery of cryptic species often helps in grasping the true diversity and detailed ecological preferences of pelagic planktons. Radiolarians are a good environmental proxy for paleontology because of their worldwide oceanic distribution and the good preservation of their shells. However, cryptic species have not yet been recognized in this planktonic protist group. In the present study, we focused on the morphospecies *Spongotrochus glacialis* with specimens collected from different layers in the Equatorial-Subtropical Pacific. A molecular phylogeny based on the internal transcribed spacer of rDNA (ITS-rDNA) sequences recovered two clades of cryptic species (types I and II) from this single morphospecies. These two distinct types were separately distributed, either in the oligotrophic surface water (type I) or below the chlorophyll maximum layer (type II). Moreover, the types showed morphological differences in the shells. Our morphometric analyses established lengths of spines as a morphological criterion to distinguish between the two types: type I with longer spines and type II with shorter spines. The length of spines is apparently associated with the habitat of each type. Type I with longer spines could be suitable for extending flagella and floating on the surface, whereas type II with shorter spines are appropriate to protrude only short flagella and dwell in deep water. Such morphological and ecological features at the cryptic species level of Radiolaria could provide new proxies for paleoceanographic studies.

Keywords: Radiolaria, cryptic species, ITS rDNA, morphometric

Japan Geoscience Union Meeting 2013
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BPO02-08 Room:105 Time:May 21 11:15-11:30

The Phylogenetic Affiliations of Radiolarian-like Environmental 18S rDNA Genes from the Northern South China Sea

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[1]The University of Tokyo

To determine the molecular taxonomic affiliations of radiolarian-like environmental 18S rDNA genes from the northern South China Sea, we constructed phylogenetic trees by the 18S rDNA sequences of identified radiolarian species, correlating environmental sequences from other sea areas with those full length 18S rDNA gene of representative clones from the northern South China Sea. In our previous work, a great number of our radiolarian-like sequences from the South China Sea were placed within the RAD-III, named by Not et al. (2007) of environmental sequences from the Sargasso Sea size-fractionated samples (< 2 micrometre). Now we found 18S rDNA sequences of two identified species Arachnosphaera myriacantha and Astrosphaera hexagonalis, collected form Okinawa Island by Yuasa etal, (2009) also belongs to RAD-III. There is a unique clade composed solely of environmental clone sequences formed basal to the Taxopodida. It dose not belong to RAD IV or V, still remains unknown. Our Nassellaria-like environmental clone from the northern South China Sea was joined with the group of described Plagoniid species. And the clones from Cariaco Basin, Caribbean clustered with Pterocorythid and Theoperids groups. Comparison of our sequences with two recent survey of Acantharia 18S rDNA, the position of northern South China Sea clones was still difficult to distinguish. It belonged to the clade composed of subgroups Arthracanthida, Sphaenacanthida and RAD I (Unidentified Clade 1). These ambiguities may be because the genetic diversity of radiolarian in warm waters sea areas is still poorly known.

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BPO02-09 Room:105 Time:May 21 11:30-11:45

Fossil cyanobacteria as a potential pH proxy for Phanerozoic ocean

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Fossil cyanobacteria appeared in the most part of Phanerozoic era, and its abundance changed significantly through time. Their fossilization related to calcification in the living state, which requires optimum chemistry in the ambient water. Therefore, the fossil record of cyanobacteria potentially reflects past ocean chemistry. Recent study revealed that cyanobacterial calcification depends mainly on pH, dissolved inorganic carbon, Ca^{2+} concentration (Shiraishi 2012, GCA). Using well-established proxies of Ca^{2+} and partial pressure of CO_2, oceanic pH was estimated from the fossil record of calcified cyanobacteria. Estimated range and trend of pH are similar to those of previous studies, but exhibited more frequent changes. In a future study, it is necessary to understand the relationship between $CaCO_3$ saturation state achieved by photosynthesis and calcification amount, in order to increase the reliability of estimation.

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BPO02-10 Room:105 Time:May 21 11:45-12:00

Benthic foraminifera as Quaternary palaeoclimate proxies in the New Caledonia Basin

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In 2001, gravity core GC4 was extracted from the New Caledonia Basin and the uppermost 141 cm, representing approximately the last 140 000 years, was investigated for chemical isotopic, carbonate, non-carbonate and trace element signatures. In this study, sub samples of the same uppermost 141 cm of GC4 were picked and sorted for all foraminiferal taxa. A total of 161 species of benthic foraminifera were obtained from the core and 46 species occurred in sufficient numbers to investigate changing patterns and trends in biodiversity and relative abundance. All changes can be related to broad scale oceanic and palaeoclimatic fluctuations during the last 140 000 years. Within GC4, two distinct foraminiferal assemblages were detected using Bray-Curtis cluster analysis and Multidimensional Scaling (MDS) analysis. Factors that influence the foraminiferal assemblages include environmental setting, SSP, oxygen levels at the sediment-water interface and transportation by oceanic current systems operating within the region.

Keywords: foraminifera

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BPO02-11 Room:105 Time:May 21 12:00-12:15

Daily light cycle reconstructed by Sr/Ca in a fossil giant clam, *Tridacna gigas*, living in 4.6 ka, southern Japan

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Giant clams are long-lived bivalvia living in a shallow tropical ocean. Their aragonite shells are potential paleo-environmental archives, i.e., oxygen stable isotopic values record paleo-seawater temperatures. Generally, trace elements in calcium carbonates are also considered as a paleo-thermometer. However, the case of Tridacninae may not follow the traditional temperature dependent fractionation, but potentially reflects insolation. This is explained by ”trans-calcification”, which is one of photosynthetically induced calcification mechanisms. Enzymatic reaction pumping Ca^{2+} to host liquid of calcification results in relatively depleted Sr/Ca ratio in day time when photosynthesis activates. Following this hypothesis, we have reconstructed the past daily light cycle.

A fossil *T. gigas*, Stg04-b was collected at Ishigaki-jima Island in Okinawa Prefecture, Japan (N24 20’0.4” E124 09’22”). Two horizons of the specimen were dated by carbon-14 method at the accelerator mass spectrometry (AMS) center of Yamagata University. The micro analyses were performed for the outer layer of 1.4 cm thickness using an electron probe micro-analyzer (EPMA), JXA8900, and a micrometer-scale secondary ion mass spectrometer (NanoSIMS), CAMECA NS50 at the Atmosphere and Ocean Research Institute (AORI), the University of Tokyo. As a result, we found clear Sr lamination parallel to the daily increment of about 20 um thickness. The hourly insolation (P) was calculated from the difference of Sr/Ca ratio (Delta-Sr/Ca) following the equation: Delta-Sr/Ca = -*a* x P, where the parameter, *a*, is defined by analysis of modern *T. maxima* [1]. Using the technique, we distinguished the sunny and cloudy seasons in 4.6 ka.

Reference
[1] Sano, Y., Kobayashi, S., Shirai, K., Takahata, N., Matsumoto, K., Watanabe, T., Sowa, K., Iwai, K. 2012, Past daily light cycle recorded in the strontium/calcium ratios of giant clam shells. Nature Commun. 3, DOI: 10.1038/ncomms1763

Keywords: giant clam, Sr/Ca, NanoSIMS

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BPO02-12 Room:105 Time:May 21 12:15-12:30

The cesspool preservation hypothesis as a key to preservation of exceptionally well preserved orsten-type fossils

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Recently, an ostracod (Crustacea, Arthropoda) specimen with exceptionally well preserved soft parts was discovered from fecal pellets rich layer at a borehole core recovered from Oppama Park, Kanagawa Prefecture, central Japan (Tanaka et al., 2012). Similar soft part-preserved arthropods have been found in the Late Cambrian Orsten limestone (Maeda et al., 2011). Such ”cesspools” were exceptionally phosphatized during early diagenesis owing to the high local phosphorus levels produced by the accumulated fecal pellets. The ”cesspool preservation hypothesis” provides an explanation for this kind of exceptional fossilization, found in the marine sediment record from the Late Cambrian onward.

Keywords: Fossil, Cambrian, Cesspool, Arthropoda, Paleontology, Holocene

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BPO02-P01 Room:Convention Hall Time:May 21 18:15-19:30

Biocalcification and teh geochemistry of proxies

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This is a joint session between JpGU and EGU Biogeosciences Devision. The name of the session is ”Biomineralisation and the geochemistry of proxies”. In my presentation, I will introduce scientific background and goals of the session.

Keywords: Biogeosciences, biomineralisation, geochemistry, proxies, EGU-JpGU Joint Session

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BPO02-P02 Room:Convention Hall Time:May 21 18:15-19:30

Assessing the environmental impact of T?hoku tsunami off Hachinohe (NE Japan): a multidisciplinary approach

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On March 11th 2011 the Japanese East coast was hit by a tsunami, which killed more than 18.000 people, caused major devastation in the coastal zone and the meltdown of 3 nuclear reactors. A magnitude 9 on the Richter scale earthquake offshore Sendai resulted in Tsunami waves reaching heights of up to 40.5 meters, which travelled 10 kilometers inland. Whereas the devastation on land is clearly visible, underwater impact is more difficult to assess. Here we present an overview of the multidisciplinary approach used to describe the benthic ecosystems off Hachinohe (NE Japan), 5 months after the T?hoku earthquake. Middle height (˜4m) of Tsunami also came to the coastal area of Shimokita Peninsula. An oceanographic cruise (cruise KT11-20? aboard R/V TANSEI MARU, AORI/JAMSTEC) took place in August 2011. An international group of Japanese, French and Dutch oceanographers, all specialists in marine ecology and marine biogeochemistry, joined this scientific mission in order to describe benthic ecosystems and fossilizing foraminiferal faunas. 4 scientific tasks were defined. The sedimentological investigation has consisted in the identification of all sedimentary evidences (physical structures and radionuclides) that illustrate hydrosedimentary processes at the seafloor (erosion, sediment gravity flow deposition). The geochemical investigation has consisted in the optimal characterization of geochemical conditions prevailing in the benthic ecosystems. A special attention has been addressed to the dissolved species (oxygen, nitrate and more) in the bottom and pore water, the organics buried in the sediment and the nature of solid phases. The faunal investigation has consisted in the ecological study of benthic foraminifera (living and dead faunas). This study has given reliable information about the response of benthic life to environmental constraints related to tsunami. The future investigation will consist in the geochemical study of trace elements in the foraminiferal shells (i.e. tests). Those overall observations should enlighten scientific community on the effect of the T?hoku tsunami on marine ecosystems off Hachinohe, and on the potential resilience of benthic communities.

Keywords: foraminifera

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BPO02-P03 Room:Convention Hall Time:May 21 18:15-19:30

Using microComputedTomography to study the impact of environmental stressors on benthic foraminifera: initial results

Helena Filipsson[1], Takashi Toyofuku[2*], Osamu Sasaki[3]

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We performed microComputedTomography (microCT) scans of benthic foraminifera, in order to better understand how multiple environmental stressors are affecting biomineralization as well as preservation of benthic foraminifera. Both live (Cell Tracker Green labeled) and dead foraminiferal specimens from the Skagerrak and Kattegat, NE Atlantic were scanned. The samples originate from 330m and 130m of water depth, where salinity ranged between 35.2 (Skagerrak) and 34.7 (Kattegat) and dissolved oxygen content varied from full oxygenated in the Skagerrak to hypoxic conditions (<2mlO2/L) at the Kattegat station. Substantial differences were noted in test (shell) preservation and morphology between fossil and modern samples, where pre-industrial samples were less affected by dissolution processes.

Keywords: foraminifera

Japan Geoscience Union Meeting 2013
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BPO02-P04 Room:Convention Hall Time:May 21 18:15-19:30

Ecological impact of the T?hoku Tsunami on shallow-water marine biodiversity off Hachinohe (NE JAPAN)

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The 11th of March 2011, Japan was struck by one of the most powerful known earthquakes, the so-called T?hoku earthquake. This earthquake presented a magnitude of 9.0 and an epicenter located 70 kilometers east of the Oshika Peninsula of T?hoku. It triggered extremely destructive tsunami waves of up to 10 meters that struck Japanese coasts. Both earthquake and tsunami caused extensive and severe structural damage in Japan. More than 15.000 people died; 8.000 are still missing. This aim of the present study is to evaluate the post-crisis environmental health of the marine biosphere from the NE Japan. In order to assess the impact of this terrible disaster on marine ecosystems, and more precisely, to assess the impact of tsunami on coastal marine ecosystems, an oceanographic cruise occured in August 2011 and sediments off Iwate prefectures (NE JAPAN) were sampled. Living benthic foraminifera collected in theses sediments were used as bio-indicators of sedimentary disturbance. Indeed, after a sediment gravity event (e.g. turbidite) triggered for instance by an earthquake, high amount of organic and inorganic detritus may be supply by lateral advection to the ocean. There, foraminiferal faunas are characterised either by recolonisation stages occurring after physical disturbance (e.g. turbidite related to tsunami) or by equilibrium phases related to gradual organic matter focussing (e.g. eutrophication). Biotic recovery after benthic crisis consists in the dominance of opportunistic pioneer species. The foraminiferal biodiversity is low. When the resilience of an ecosystem is surpassed (after weeks, months or years), opportunistic taxa are generally replaced by highly specialised communities. Then, the foraminiferal diversity increases. In case of the T?hoku Tsunami, the inherent question is: Do benthic Foraminifera indicate environmental alteration/resilience of marine biodiversity in relation to tsunami?

Keywords: foraminifera

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BPO02-P05 Room:Convention Hall Time:May 21 18:15-19:30

First-order estimate of the planktic foraminifer biomass in the modern global ocean

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Planktic foraminifers are heterotrophic mesozooplankton of global marine abundance ubiquitously used in paleoecology, paleoceanography, and paleoclimate reconstruction. However, the biomass and trophic role of planktic foraminifers was largely unknown. To better understand the position of planktic foraminifers within the regional and global plankton, we have developed a new analytical method and quantified the individual and species specific planktic foraminifer biomass. With a new non-destructive protocol developed from the bicinchoninic acid (BCA) method and nano-photospectrometry, we have analysed the foraminifer protein-biomass, along with test morphometry. From additional CHN analysis, it can be assumed that protein biomass equals carbon-biomass. The foraminifer cytoplasm is exposed to the analytical reagents without breaking the test by applying an osmotic shock. The new method is quick and easy to apply, and we have so far produced a data set of the protein-biomass in function of test size of 21 planktic foraminifer species from Atlantic, Pacific, and Southern Ocean waters.

Our data include a wide range of oligotrophic to eutrophic conditions covering six orders of magnitude of assemblage biomass. Samples include symbiont bearing and symbiont-barren species from the sea surface down to 2500 m water depth. Being secondary producers with an omnivorous diet, which ranges from algae to small metazoans, planktic foraminifers are not limited to a single food source, and are assumed to occur at a balanced abundance displaying the overall marine biological productivity at a regional scale. Accordingly, the average individual planktic foraminifer protein- and carbon biomass amounts to 0.845 ug. Conversion factors between individual biomass and assemblage-biomass are calculated for test sizes between 72 and 845 um (minimum test diameter). Assemblage-biomass data presented here include 1128 sites and water depth intervals. The regional coverage of data includes the North Atlantic, Arabian Sea, Red Sea, Caribbean, as well as literature data from the eastern and western North Pacific off Japan, and covers a wide range of oligotrophic to eutrophic waters over six orders of magnitude of planktic foraminifer assemblage-biomass (PFAB). A first order estimate of the average global planktic foraminifer biomass production (>125 um) ranges from 8.2-32.7 Tg C yr-1 (i.e. 0.008-0.033 Gt C yr-1), and might be more than three times as high including neanic and juvenile individuals adding up to 25-100 Tg C yr-1. However, this is a first estimate of regional PFAB extrapolated to the global scale, and future estimates based on larger data sets might considerably deviate from the one presented here. This paper is supported by, and a contribution to the Marine Ecosystem Data project (MAREDAT). Data are available from http://www.pangaea.de (http://doi.pangaea.de/10.1594/PANGAEA.777386).

Keywords: foraminifera

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Vertical migration, nitrate uptake and denitrification: survival mechanisms of foraminifers under low DO conditions

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15NO3 - isotope labelling experiments were carried out to study foraminiferal nitrate uptake strategies and the role of pseudopodial networks in nitrate uptake. Globobulimina turgida were placed below the nitrate penetration depth in homogenised sediment cores, which were subsequently incubated in artificial seawater containing the label. The physical migration of foraminifera to strata containing nitrate and oxygen was prevented by a nylon net, however, potential access to such strata by extension of pseudopods was still possible. As no 15NO3 - was found in G. turgida in the experimental cores, we concluded that foraminifera cannot extend their pseudopods for nitrate uptake through several millimetres of sediment. In stead they must physically migrate upwards closer to nitratecontaining strata. The foraminiferal migration patterns in the control cores (with no nylon net) were observed to be erratic, suggesting that individuals move in random orientations until they find favourable conditions (i.e. free nitrate or oxygen).

A second experiment showed that foraminifera actively collect nitrate in both the presence and absence of oxygen, although uptake was initiated faster if oxygen was absent from the environment. However, no systematic influence of the size of the intracellular nitrate pool on nitrate uptake was observed, as specimens containing a large range of intracellular nitrate (636-19992 pmol/cell) were measured to take up 15NO3 - at comparable rates.

Keywords: foraminifera

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BPO02-P07 Room:Convention Hall Time:May 21 18:15-19:30

Seawater Mg/Ca variability during the Middle Miocene Climate Optimum

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Variability in seawater [Ca2+] and [Mg2+] over timescales >1 Ma challenges the use of foraminiferal Mg/Ca as a temperature proxy. Since temperature and seawater Mg/Ca both determine foraminiferal Mg/Ca, reconstructed temperatures need to be corrected for past seawater Mg/Ca when applied to long timescales. Currently, such corrections are based on models with a low temporal resolution and relatively large uncertainty in past seawater Mg/Ca. Moreover, when applying correction factors it is assumed that the sensitivity of the Mg/Ca-temperature calibration is not affected by seawater Mg/Ca. To quantify the combined impact of seawater Mg/Ca and temperature on foraminiferal Mg/Ca, we conducted a set of culturing experiments in which these parameters were manipulated independently. The combined effect of seawater Mg/Ca and temperature on calcite Mg/Ca in a hyaline (Elphidium crispum) and a miliolid (Quinqueloculina sp.) species was determined by laser ablation-ICP-MS.

The dependencies of calcite Mg/Ca on these two parameters for both species were used to reconstruct seawater Mg/Ca over the Middle Miocene Climatic Optimum (MMCO) from the Equatorial Pacific using IODP core 1338. Using the different Mg-incorporation mechanisms of hyaline and miliollid foraminifera reveals that seawater Mg/Ca for this interval is on average different and more variable than previous studies suggested. The accompanying deep sea temperatures for this interval are on average lower than previously reported. This new reconstruction also shows that variability in seawater Mg/Ca warrants high resolution reconstructions when correcting temperatures based on foraminiferal Mg/Ca.

Keywords: foraminifera

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Seasonality in the Arabian Sea over glacial-interglacial cycles

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The Indian monsoon system controls seasonal precipitation alterations over the Indian continent and upwelling of nutrient-rich waters to the surface in the northern Arabian Sea. Functioning and strength of this weather system due to climate change is one of the important issues in predicting the effects of global warming on the region's economy, agriculture and social welfare. The strength of the Indian monsoon system through time can be studied by changes in seawater temperature and chemistry from single-specimen analysis of planktic foraminiferal calcite. Temperature reconstructions based on many single specimens allow reconstruction of past seasonal sea water temperatures ranges and thus seasonal temperature variability. .

Here we present seawater reconstructions based on single-specimen Mg/Ca of the surface dweller Globigerinoides ruber and the deeper-living G. dutertrei of two sediment cores of the western equatorial Indian Ocean off Tanzania and the northern Arabian Sea. From both cores, specimens are analyzed for calcitic Mg/Ca using laser ablation-ICP-MS of time-intervals representing the Holocene optimum, Last Glacial Maximum, Marine Isotope Stage 4, MIS 5 and MIS6. The resulting temperature ranges allow reconstruction of variability in the strength of the Indian Monsoon as well as cross-equatorial heat transport during glacials and interglacials.

Keywords: foraminifera

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Temperature-controlled experiments for the shell microstructural formation of S. broughtonii (Mollusca: Bivalvia)

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A temperature experiment was performed to corroborate the thermal control of microstructural formation, and the cultured specimens were found to exhibit differences in shell formation by temperature. It has been suggested that the cyclical changes in the shell microstructures of *S. broughtonii* might be affected by temperature seasonality based on a study of field specimens (Nishida et al., 2012). This is the first report of temperature experiments in relation to the microstructural formation of shells. Additionally, this experiment contributes to the reconstruction of the paleoenvironments using shell microstructures and to our understanding of the mechanisms of shell microstructural formation.

We cultured specimens of *S. broughtonii* under five different temperature conditions at the Demonstration Laboratory, Marine Ecology Research Institute (MERI) in Kashiwazaki City, Niigata Prefecture, Japan. The investigated temperatures were 13 C, 17 C, 21 C, 25 C, and 29 C, and the specimens were cultured for approximately 58 days. We placed 5 aquariums (12 liters) in the laboratory with 5-7 specimens placed in each aquarium. We removed part of the marginal periostracum to determine shell growth during the experiment.

The shell sizes and increment of the shell deposition during the experiment show that the most rapid growth occurs at 17 C. Based on the d18O data, the specimens at 17 C, 21 C, 25 C, and 29 C formed shell material at each temperature condition. The thickness of the composite prismatic structure increases at higher water temperatures, and this trend is same as that of the field specimens. The specimen at 17 C showed the sharpest edge in the marginal part of the outer layer in comparison to the specimens cultivated at 21 C, 25 C, and 29 C. Accounting for the outer layer, the area of the composite prismatic structure increases as the water temperature is reduced. The growth increment of the crossed lamellar structure was relatively constant, whereas that of the composite prismatic structure increased rapidly as the thickness of the composite prismatic structure increased at cooler temperatures. This finding suggests that the optimum temperature for *S. broughtonii* growth as determined experimentally is consistent with the shell growth in the temperate area and that the formation of the composite prismatic structure increases the shell growth, especially the expansion of the growth increments in the outermost part of the outer layer.

Keywords: Bivalve, shell microstructure, Stable oxygen isotopes, temperature experiment, shell growth

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Phosphorus speciation analysis of sediments in the hypersaline Meedee Lake, off Crete Island, Eastern Mediterranean Sea

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Submarine, hypersaline lakes have been found off Crete Island, Eastern Mediterranean Sea. Among them,"Meedee Lake" has a unique environment where its salinity is more than 10 times higher than that of normal seawater, due to elution of submarine evaporites formed during Messinian Salinity Crisis (MSC) 5.33 to 6 Ma ago. The lake water has been kept essentially anoxic due to consumption of dissolved oxygen by decomposition of organic matter in a density-stratified lake. In order to understand changing redox state, environments, and microbial activity in the lake, sediments core was collected by KH06-04 cruise. The sediments show alternation of light- and dark-colored layers. Reflecting fluctuating redox state during deposition (Izumitani, 2010).

Phosphorus is one of the bio-essential elements for life on earth and plays an important role in regulating biological productivity in oceans and on continents (Van Cappelen and Ingall, 1994, 1996). Influenced by microbial activity, redox state, and diagenesis, P exists as various forms in marine sediments. Thus, P speciation could be an important clue for better understanding of sedimentary environments. We applied phosphorus speciation analysis for the sediments to quantify transition of redox sensitivity.

Five sedimentary P reservoirs were separately quantified: (1) loosely sorbed P+biogenic apatite+CaCO3-associated P, (2) Fe-bound P, (3) authigenic carbonate fluorapatite (CFAP). (4) Detrital apatite P, by using five-steps sequential extraction technique following the method of Hashimoto (2010), based on Ruttenberg (1992) and Schenau and de Lange (2000). Molybdenum blue method was applied to determine P concentration by using an UV-VIS spectrophotometer.

CFAP concentration was much higher than other forms, accounting for 76% of light colored layers and 67% of dark colored layers. Concentration of organic P (Porg) and detrital apatite P (Pdet) were much lower than expected. The largest concentration differences between light- and dark-colored layers were Fe-bound P (PFe), and its concentration decreases with sediment lightness. possibly,reflecting transition of redox state. Under anoxic condition, phosphate was released from Fe-(oxyhydr)oxides during their reductive dissolution, indicating deposition of light-colored layer under anoxic condition and dark-colored layer under oxic condition. This suggestion is consistent with the results of Izumitani (2010).

Generally, abundance of organic matter in surface sediments decreases with increasing concentration of oxygen in porewater and overlying water. Then Porg content is expected to decrease; however, an opposite result was obtained. This discrepancy was probably caused by either of following factors. First, sinking particles of organic matter may have some difficulty in penetrating the hypersaline dense lake water. Furthermore, benthic foraminifera was relatively large in number and high in diversity in dark-colored layers (Izumitani, 2010). Therefore, the origin of Porg in dark-colored layers may possibly be benthic foraminifera. Second, influence of climate change may have some effects on the sedimentary environment of the saline lake. Izumitani (2010) suggested that, using the same core, the light-colored layers deposited in interglacial periods and the dark-colored layers in glacial periods. Deposition of organic matter was enhanced in the glacial periods because of increasing biological productivity during eutrophication in ice-covered ocean.

CaCO3-associated P concentration would be the largest where foraminifera are abundant, but CFAP concentration was much higher than the other P-bearing forms. This is probably because changing decomposition rate of phosphorus in Meedee Lake led PFe and Porg to alternate with CFAP, or because CFAP concentration reflects concentration of abiotically-formed CaCO3 derived from evaporite minerals formed during MSC.