

BPT002-01

会場:201B

時間:5月25日 08:30-08:45

## 琉球列島産現生腕足動物 (*Basiliola lucida*) 殻の炭素・酸素同位体組成の個体差 Intraspecific Variations in Carbon and Oxygen Isotope Compositions of a Modern Brachiopod Collected off Okinawa-jima

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Carbon ( $d^{13}C$ ) and oxygen ( $d^{18}O$ ) isotope compositions in rhynchonelliform brachiopod shell calcite have been widely used as proxies of  $d^{13}C$  of dissolved inorganic carbon (DIC) and  $d^{18}O$  of ancient seawater, respectively. The use of brachiopods as a paleoenvironmental proxy is based on the presupposition that the shell calcite is precipitated in isotopic equilibrium with ambient seawater. Recently, it was shown that the modern brachiopod calcite display variable carbon and oxygen isotope offsets from the range of equilibrium calcite (= calcite precipitated in isotopic equilibrium with ambient seawater) even within a single shell and degree of the disequilibrium varies from species to species [e.g., Auclair *et al.*, 2003, *Chem. Geol.*, 202, 59-78; Yamamoto *et al.*, 2010a, *Palaeo-3.*, 291, 348-359; Yamamoto *et al.*, 2010b, *G-cubed*, 11, Q10009]. However, a single specimen was examined for each species in the previous studies that dealt with within-shell variations. Therefore, further geochemical investigations are needed to reveal intraspecific variations in isotopic compositions to establish the isotopic compositions of brachiopod shells as a much more reliable paleoenvironmental proxy.

This study presents intraspecific variations in carbon and oxygen isotope profiles along the growth axis of modern brachiopod shells of *Basiliola lucida* collected from shelf to shelf slope environments (180-320 m water depth) off Okinawa-jima and Amami-o-shima, southwestern Japan. The  $d^{13}C$  and  $d^{18}O$  values of each shell are rather constant with no significant variations. The  $d^{13}C$  values are greater than those of equilibrium calcite with two outlier shells. The  $d^{18}O$  profiles show enrichment in  $^{18}O$  relative to equilibrium calcite throughout the growth axis, which underestimates seawater temperature, although the differences in the  $d^{18}O$  values among the samples correspond to those of seawater temperatures among the brachiopod growth sites. Significant offsets of  $d^{13}C$  and  $d^{18}O$  values from the range of equilibrium calcite indicate that the isotopic compositions in the shells of *B. lucida* are influenced by vital effects that are generally explained by kinetic fractionation and metabolic effects. However, the degrees of the effects on  $d^{13}C$  and  $d^{18}O$  values are comparatively constant in each individuals. In conclusion, the use of *B. lucida* as a proxy of ancient seawater temperature is not very recommend. However, if water depths of the brachiopod-yielding horizons are determined independently by other fossils (e.g., benthic foraminifers) in a given geologic section,  $d^{18}O$  value of *B. lucida* can be used as a proxy to determine depth gradient of seawater temperature for the past.

キーワード: 腕足動物, 炭素同位体組成, 酸素同位体組成, 沖縄沖, 奄美沖

Keywords: brachiopod, carbon isotope composition, oxygen isotope composition, off Okinawa-jima, off Amami-o-shima

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## ガンジス川およびブラマプトラ川堆積物の地球化学的研究 Geochemistry of sediments from the Ganges and Brahmaputra Rivers

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World-scale big rivers play an important role in the transportation of river water and particles to the ocean. The Ganges and Brahmaputra rivers are especially important for reconstruction of Himalayan monsoon climate. Chemical compositions of the Ganges and Brahmaputra River sediments have been determined to investigate their provenance and source area weathering conditions.

Major and trace element concentrations normalized to upper continental crust (UCC) show the sediments in both rivers are depleted in CaO, K<sub>2</sub>O, Na<sub>2</sub>O, Sr, MgO, Al<sub>2</sub>O<sub>3</sub> - Sc and Fe<sub>2</sub>O<sub>3</sub> and enriched in Zr, Th, Ce, SiO<sub>2</sub>, Y, TiO<sub>2</sub> and Cr. Silica enrichment is caused by quartz concentration, mineral sorting and/or enhanced compositional maturity during fluvial transportation. Chemical Index of Alteration (CIA) ratios in the river sediments (Ganges, ~64 and Brahmaputra, ~60) are low compared to those of Miocene Sylhet sediments in Bangladesh (mostly ~70-87). CIA ratios are low in the river samples because they mostly contain fresh sandy material within the active channels, while highly weathered fine-grained detritus has been transported by the river waters into the ocean. Major element and trace element ratio plots indicate the sediments in both rivers were derived from felsic continental crust sources. A - CNK - FM relationships further suggest minimal weathering of the modern sediments, major contribution from felsic materials, and minor ferromagnesian mineral content. Chemical similarity of the river sediments, the Sylhet and the equivalent Siwalik sequence sedimentary rocks in Nepal represents homogenization of material derived from the Himalayan source, and no major compositional changes have occurred in the source during the last 20 million years.

Keywords: river, sediments, climate, weathering

BPT002-03

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## 放射性炭素年代測定を用いた、沖縄県久米島下地原鍾乳洞石筍の年代モデル構築 Age models of stalagmite from Shimochibaru cave in Kume Island, using radiocarbon dating

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古環境復元のプロキシとしての石筍には、分布地域が限られておらず、世界中の石灰岩地域に石筍が存在すること、千年から10万年スケールで連続的に成長するため、長期記録を得ることができること、そしてウラン系列の年代測定を用いて、60万年前までの正確な年代測定ができることなどの利点があり、近年多くの研究例が報告されている(たとえば Wang et al., 2005)。一般に、放射性同位体を用いた石筍の年代決定は、ウラン系列核種を用いた方法が用いられているが、本研究では、約5万年前までの年代測定が可能であり、少量のサンプルで測定可能な放射性炭素年代測定を用いて石筍の年代モデル構築の可能性について検証を行った。石筍の場合、ambient atmospheric carbon (大気中の同位体比を持つ炭素)のみでなく、母岩である石灰岩からの dead carbon (固定されてから時間が経過し、<sup>14</sup>Cに枯渇した炭素)の混入があるため、サンプル中の<sup>14</sup>C濃度から直接年代を計算することはできない。しかし、成長期間を通じて dead carbon の混入割合を一定と仮定してその効果を補正することで、成長年代を得ることができる可能性が示唆されている (Beck et al., 2001)。

今回得られた久米島の下地原鍾乳洞から採取した石筍は、X線粉末回折を用いた組成分析によって、純粋な Calcite であることが確認された。久米島下地原鍾乳洞から採取した石筍のうち全長約24cm(石筍A)と約173cm(石筍B)のものを、成長軸に沿ってサンプリングを行い、加速器質量分析装置を用いて放射性炭素年代測定を行った。

放射性炭素年代測定で得られた結果より、Lambert & Aharon (2011)に従って dead carbon の混入割合を計算した。下地原鍾乳洞で採取した3つの石筍の先端部の計算結果から、採取時まで成長していた石筍の先端部でも、約20%の dead carbon の混入があることがわかった。この結果を元に、石筍が成長していた期間、dead carbon の混入割合は常に一定であったと仮定して年代値の補正を行った。

その結果、石筍Aでは、成長方向と年代の逆転が全く見られない年代モデルが得られた。最上部から10cmより深部では、成長速度一定で連続的に成長していたことがわかり、ハイエイタスの存在が示唆される部分については、サンプルの縞の観察と年代モデルが一致した。連続的に成長していた部分の成長速度は0.25m/yrであり、先行研究(例えば Wang et al., 2005)や琉球石灰岩地帯の石筍の成長速度(神谷, 2007)と整合的なものであった。

一方、石筍Bは先端部付近の多少のばらつきはみられたものの、ほぼ一定の成長速度で成長していたことがわかった。成長速度は約1mm/yrであり、Bと比較して4倍の速い値を示した。

今回の結果から、ウラン系列による年代測定を行わなくても、dead carbon の混入割合を適切に補正することにより、放射性炭素年代測定から簡便に石筍の年代モデルを導くことができる可能性が示された。また、年代モデルから成長速度を計算することで、環境復元に適したサンプルであるか否かが判断できることが示唆された。今後はウラン系列各種を測定し、これらの結果の妥当性についても検証していく予定である。

キーワード: 石筍, 放射性炭素年代, 年代測定, 久米島

Keywords: stalagmite, radiocarbon age, dating, Kume Island

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## 完新世中期の西太平洋熱帯域表層における海水温および海水の酸素同位体比の復元 Reconstruction of temperature and oxygen isotopes in the surface water of the Mid-Holocene tropical western Pacific

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Oxygen isotope ratios ( $d^{18}\text{O}$ ) in foraminifera from deep sea cores have been used successfully to reconstruct continental ice volume, sea level and deep-ocean temperatures throughout the last glacial-interglacial cycle. Yet there is still considerable debate regarding the relative contributions of changes in the oxygen isotopic composition of seawater in the tropical surface ocean. Obtaining accurate estimate of the past  $d^{18}\text{O}$  distribution in tropical surface waters is crucial to establishing the role of the tropical oceans in global climate change. In this study, Sr/Ca ratios and  $d^{18}\text{O}$  values in a fossil coral collected from Vanuatu with the age of 5.2 ka were measured to reconstruct past sea surface temperature (SST) and  $d^{18}\text{O}$  in seawater. XRD analysis and SEM observation revealed that skeletal material was composed of only aragonite and the age determination was precisely conducted using U-Th dating method. Then Sr/Ca and  $d^{18}\text{O}$  were analyzed with an approximate time resolution of 2 month. As a result, slightly higher mean SST and about 0.4 per mil enrichment of  $d^{18}\text{O}$  relative to modern seawater have shown from 5.2 ka coral. The result is corresponding to the previous study from Great Barrier Reef which has suggested that the temperature increase enhanced the evaporative enrichment of  $^{18}\text{O}$  in seawater.

Keywords: western Pacific, coral Sr/Ca, oxygen isotope, Holocene

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## 中期-後期完新世のスリランカ海水準変動からもたらされる南極氷床変動の情報 Detecting Antarctic melting during the Holocene using sea-level information from Sri Lanka

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Mid to Late Holocene sea-level change can be used for evaluating long-term stability of the Antarctic ice sheet since the most of the Northern hemisphere major ice sheets disappeared by approximately 8,000 years ago. Ongoing global warming may trigger disintegration of this ice sheet, with collapse of the West Antarctic Ice Sheet alone potentially producing a more than 3 to 4 m global sea-level rise. Relative sea level records from sites far away from former ice sheet regions (far-field) provide information on total volume of the ocean mass change, which can be interpreted as global ice volume change. Here we report Holocene sea-level records from Sri Lanka compared with glacio-hydro-isostatic modeling to better understand the melting history of Antarctic ice sheet during the Holocene.

キーワード: 海水準, 完新世, 南極, アイソスタシー, 堆積物コア, 放射性炭素年代測定

Keywords: Sea Level, Holocene, Antarctica, Isostasy, sediment core, Radiocarbon dating

BPT002-06

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## 海洋酸性化に対する底生大型有孔虫の石灰化応答 Effects of ocean acidification on calcification of symbiont-bearing reef foraminifers

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Ocean acidification (decreases in carbonate ion concentration and pH) in response to rising atmospheric pCO<sub>2</sub> is generally expected to reduce rates of calcification by reef calcifying organisms, with potentially severe implications for coral reef ecosystems. Large, algal symbiont-bearing benthic foraminifers, which are important primary and carbonate producers in coral reefs, produce high-Mg calcite shells, whose solubility can exceed that of aragonite produced by corals, making them the "first responder" in coral reefs to the decreasing carbonate saturation state of seawater. Here we report results of culture experiments performed to assess the effects of ongoing ocean acidification on the calcification of symbiont-bearing reef foraminifers using a high-precision pCO<sub>2</sub> control system. Living clone individuals of three foraminiferal species (*Baculogypsina sphaerulata*, *Calcarina gaudichaudii*, and *Amphisorus hemprichii*) were subjected to seawater at five pCO<sub>2</sub> levels from 260 to 970 ppm. Cultured individuals were maintained for about 12 weeks in an indoor flow-through system under constant water temperature, light intensity, and photoperiod. After the experiments, the shell diameter and weight of each cultured specimen were measured. Net calcification of *Baculogypsina* and *Calcarina*, which secrete a hyaline shell and host diatom symbionts, increased under intermediate levels of pCO<sub>2</sub> (580 and/or 770 ppm) and decreased at a higher pCO<sub>2</sub> level (970 ppm). Net calcification of *Amphisorus*, which secretes a porcelaneous shell and hosts dinoflagellate symbionts, tended to decrease at elevated pCO<sub>2</sub>. These different responses among the three species are possibly due to differences in calcification mechanisms (in particular, the specific carbonate species used for calcification) between hyaline and porcelaneous taxa, and to links between calcification by the foraminiferal hosts and photosynthesis by the algal endosymbionts. Our findings suggest that ongoing ocean acidification might favor symbiont-bearing reef foraminifers with hyaline shells at intermediate pCO<sub>2</sub> levels (580 to 770 ppm) but be unfavorable to those with either hyaline or porcelaneous shells at higher pCO<sub>2</sub> levels (near 1000 ppm).

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## Speed of environmental change and ocean acidification Speed of environmental change and ocean acidification

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Warm tropical ocean is analogy of those in Cretaceous and the Paleocene/Eocene transition. But both showed different features. In the late Albian, the deep sea temperature is estimated at about 15 degree C in the equatorial Pacific and atmospheric CO<sub>2</sub> concentrations is suggested to vary between about 2 and 5 times more than that at present atmospheric pCO<sub>2</sub>. Larger oceanic alkalinity content can also be argued from the perspective of the production of calcifying organisms at the surface. Recently Zondervan et al. (2001) pointed out that an acidification of the ocean slows or prevents growth of calcifying primary producers. So the fact that we see some carbonate preservation during the Albian suggests that the ocean surface was sufficiently basic, despite higher atmospheric pCO<sub>2</sub>, to allow growth of calcifying producers. In contrast, The P/En is characterized by large excursion in the oxygen and carbon isotope records due to the disintegration of methane hydrate and the most dramatic extinction of 35-50% of cosmopolitan benthic foraminifera in the past 100 m.y.. ODP Leg 199 Site 1220 provides a continuous sedimentary section across the P/E boundary in the carbonate-bearing sediments on 56-57 Ma oceanic crust. The methane is expected to be rapidly oxidized to carbon dioxide. Because of an acidic gas, CO<sub>2</sub> will lead to a reduction in deep-sea pH. A pH decrease was very likely responsible for the emergence of agglutinated foraminiferal fauna as calcareous fauna was eliminated by acidification at the P/E transition at Site 1220.

キーワード: Speed, nvironmental change, ocean acidification

Keywords: Speed, nvironmental change, ocean acidification

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## Subtropical coral records of Northern Hemisphere climate variability and abrupt surface ocean salinity changes Subtropical coral records of Northern Hemisphere climate variability and abrupt surface ocean salinity changes

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Subtropical corals provide an ultra-high resolution archive of past temperature and salinity variations at the sea surface. In contrast to tropical corals, which primarily document interannual variability associated with the El Niño-Southern Oscillation, subtropical coral records document mid- to high-latitude atmosphere-ocean variability. Due to their sub-seasonal resolution, these coral records allow to reconstruct climate variability for individual seasons such as boreal winter, which is still underrepresented in high-resolution proxy reconstructions of the last millennium. The northern Red Sea and the western North Pacific Ocean represent unique locations at the western and eastern margins of the Asian continent, where ocean currents transport warm tropical waters to higher latitudes, enabling coral reef growth at subtropical latitudes. Coral oxygen isotope records in the northern Red Sea (28-29 deg N) were shown to reflect a combined signal of aridity and temperature variations and document atmospheric variability of the Arctic Oscillation/North Atlantic Oscillation (AO/NAO). Coral Sr/Ca and U/Ca records in the western subtropical North Pacific Ocean (27 deg N) were shown to reflect temperature variations and document the oceanic variability of the Pacific (inter)Decadal Oscillation (PDO). Combined analysis of oxygen isotope and Sr/Ca (U/Ca) ratios in corals enables to reconstruct past changes in salinity at annual or higher resolution. Surface ocean salinity is a major component in climate dynamics. However, continuous salinity observations in the surface ocean are scarce prior to 1970, and the magnitude of salinity changes during the last centuries is largely unknown. A coral record from the western subtropical North Pacific indicates that an abrupt regime shift toward fresher surface ocean conditions in this region occurred during the early 20th century, between 1905 and 1910 A.D.. This abrupt freshening resulted from a combination of atmospheric and oceanic advection processes, including a weakening of the westerlies that transport dry continental air from Asia to the North Pacific. New coral Sr/Ca data from the northern Red Sea, in combination with oxygen isotopes, reveal that an abrupt regime shift toward fresher surface ocean conditions occurred in this region at the end of the Little Ice Age, between about 1850 and 1855 A.D.. Possible mechanisms for this abrupt freshening in the northern Red Sea, such as the re-organization of the Northern Hemisphere atmospheric circulation at the end of the Little Ice Age, will be discussed.

キーワード: coral paleoclimatology, oxygen isotopes, trace elements, Northern Hemisphere, Last centuries, Porites corals  
Keywords: coral paleoclimatology, oxygen isotopes, trace elements, Northern Hemisphere, Last centuries, Porites corals



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## タヒチサンゴ化石から推定される南太平洋熱帯域の海洋環境 Tropical South Pacific Climate Variability Inferred from Tahiti Fossil Corals: IODP Expedition 310 -Tahiti Sea Level-

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Ryuji Asami<sup>1\*</sup>, Thomas Felis<sup>2</sup>, Pierre Deschamps<sup>3</sup>, Kimio Hanawa<sup>4</sup>, Yasufumi Iryu<sup>5</sup>, Edouard Bard<sup>3</sup>, Nicolas Durand<sup>3</sup>, Masafumi MURAYAMA<sup>6</sup>

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Massive Porites corals, living in shallow waters of the tropical to subtropical oceans, precipitate annually-banded aragonite skeletons. These colonies provide robust chronological control and allow sampling at subseasonal resolution. Ages of fossil corals can be determined accurately by radiocarbon and uranium/thorium dating. Coral strontium/calcium (Sr/Ca) ratio has been widely used as a robust paleothermometer (e.g., Beck et al., 1992). Coral oxygen isotopes (d18O) reflect variations in sea surface temperature and seawater d18O with the latter being closely related to salinity reflecting the precipitation/evaporation balance at the sea surface and changes in water mass transport (e.g., Tudhope et al., 1995). Therefore, coupled determinations of Sr/Ca and d18O in a coral enable the construction of proxy records for both sea surface temperature and salinity (e.g., Gagan et al., 1998, Felis et al., 2009). Fossil corals were shown to provide subseasonally-resolved proxy records of sea surface temperature and salinity for time windows of the Holocene, the last glacial period and older interglacials. However, most fossil reefs of glacial age are located today at water depths of >100 m, as a result of the lower sea level caused by ice sheet build-up during glacial periods (e.g., Bard et al., 1990). Therefore, it has been difficult to collect corals of glacial and deglacial age for paleoclimatic studies.

In 2005, the Integrated Ocean Drilling Program (IODP) Expedition 310 (Tahiti Sea Level), conducted by the European Consortium for Ocean Research Drilling-Science Operator using the mission-specific platform (DP Hunter), drilled the coral reef system off Tahiti (French Polynesia), an island located in the central tropical South Pacific (Camoin et al., 2007). During the expedition, massive fossil coral colonies, mostly of Porites, were recovered in-situ at depths of about 40 to 150 m below modern sea level. We present monthly resolved Sr/Ca and d18O records from well-preserved fossil corals recovered during the expedition (Asami et al., 2009). Our coral-based estimates of sea surface temperature and seawater d18O document thermal and hydrologic variations around Tahiti for selected time windows during the Quaternary, furthering our understanding of tropical South Pacific climate change that accompanied the sea-level change.

Keywords: coral skeleton, Tahiti, oxygen isotope composition, paleothermometer, tropical South Pacific, IODP

BPT002-10

会場:201B

時間:5月25日 11:30-11:45

## 北西太平洋4島のサンゴが記録する、PDOやEAWM(東アジア冬季モンスーン)に関連した10年規模気候変動

### PDO- and East Asia Winter Monsoon-related variability detected in coral records from 4 islands in the North Pacific Gyre

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Ayaka Fukushima<sup>1\*</sup>, hodaka kawahata<sup>2</sup>, Atsushi Suzuki<sup>3</sup>, Keitaro Kojima<sup>4</sup>, Takashi Okai<sup>3</sup>, Toyoho Ishimura<sup>3</sup>, Fernando P. Siringan<sup>5</sup>

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Decadal variations in the East Asian Monsoon, Pacific Decadal Oscillation (PDO), as well as El Nino Southern Oscillation (ENSO), are considered to play an important role for the regional climate of the NW Pacific. Their interactions may evolve under the progress of the global warming. However, our knowledge on the future climate is limited mostly due to the lack of long-term and precise records. Here we compared the centennial-long  $d^{18}O$  and Sr/Ca records in modern *Porites* corals from four sites along the North Pacific Gyre in order to examine past changes in the relationship among the major climate variability. By applying a possible regime shift detection method, it was revealed that evident PDO pattern dominated in the records from the mid-ocean sites, Ogasawara (27°6'N, 142°11'E) and Guam (13°35'N, 144°50'E). In contrast, corals from Ishigaki (12°10'N, 124°20'E) and Bicol (13°03'N, 124°01'E), proximal sites to the continent, indicated strong influence of the East Asian Winter Monsoon, with an evident decreasing trend in its decadal component. Interestingly, both Ishigaki and Bicol records during the 19th century showed significant covariation linked to the PDO, suggesting the PDO as the ruling variability all over the NW Pacific in the past. Weakening of the decadal component of winter monsoon intensity and PDO influence in the marginal sites of the NW Pacific may be associated to impaired Siberian High development during winter while the Aleutian Low remains unchanged under the global warming trend in the 20th century.

キーワード: 太平洋十年規模振動, 東アジア冬季モンスーン, サンゴ骨格気候学, 北西太平洋, レジームシフト

Keywords: Pacific Decadal Oscillation, East Asian Winter Monsoon, coral skeletal climatology, North Pacific Gyre, climatic regime shift

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BPT002-11

会場:201B

時間:5月25日 11:45-12:00

## 喜界島サンゴ骨格を用いた過去432年間の海洋環境復

## A 432-year-long paleoceanographic record in Porites coral in Kikai Island, Southern Japan

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In June 2009, we obtained a long modern core from a coral reef in Kikai Island, Japan. The island is located on the eastern boundary of the East China Sea in the northwestern Pacific. The coral core is approximately 440 cm long and dates back to 432 years (1578-2009 A.D.) including the Little Ice Age (LIA).

The LIA was a time when Europe and other regions neighboring the North Atlantic experienced colder conditions between the 16th to mid-19th centuries. It is reported that this was characterized by the most extensive period of mountain glacier expansion in the recent past. However, owing to the sparseness of the available proxy data during the LIA, there is still no consensus concerning its spatial pattern, timing and cause. In particular, there is a lack of records in the Pacific during the LIA. Thus our 432-year-long coral record from Kikai Island is a useful tool to understand the global-scale picture of climate change during the LIA.

Here we show a continuous 432-year record of sea surface temperature and other parameters based on coral paleo-climate proxies including trace elements, such as Sr, U, and Ba. We analyzed the skeletal elements using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). This is a very powerful tool to handle long-term records since it requires a relatively brief experimental time compared with analysis using isotope dilution or thermal ionization ICP-MS. Based on these results, we discuss the paleoceanographic conditions in the northwestern Pacific during the LIA.

キーワード: サンゴ, レーザーアブレーション ICP-MS, 小氷期, 東アジアモンスーン, 太平洋十年規模振動  
Keywords: Coral, Laser Ablation ICP-MS, Little Ice Age, East Asian Monsoon, Pacific Decadal Oscillation

BPT002-12

会場:201B

時間:5月25日 12:00-12:15

## ハマサンゴ骨格における Mg 同位体分別：飼育実験による低緯度域の新規古気候プロキシの評価

### Mg isotope fractionations in *Porites* coral skeletons: evaluation of a new climate proxy from culture experiments

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Toshihiro Yoshimura<sup>1\*</sup>, Hodaka Kawahata<sup>2</sup>, Atsushi Suzuki<sup>3</sup>, Mayuri Inoue<sup>2</sup>, Masaharu Tanimizu<sup>4</sup>, Kanako Koga<sup>5</sup>, Kazuhiko Sakai<sup>5</sup>

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Recent developments in inorganic mass spectrometry have allowed new stable isotope systems to be explored by paleoceanographers. In the field of low-latitude climate reconstruction, proxy developments in massive hermatypic corals are still highly desirable for more accurate temperature reconstructions. Stable isotope compositions of the major and minor constituents, such as Ca and Sr, of coral aragonite are potentially new proxies for environmental studies (Bohm et al., 2006; Fietzke and Eisenhauer, 2006). These studies have focused on the temperature dependency of isotope fractionation during the precipitation of biogenic carbonates, because water temperature is the most fundamental parameter controlling the earth's surface environment. Although Sr/Ca is regarded as useful temperature proxy, Mg/Ca is thought to mainly reflect the growth rate (e.g., Inoue et al., 2007). Evaluation of Mg isotope fractionation process in hermatypic coral aragonite must be addressed in order to understand a coral biomineralization and develop a new palaeoceanographic proxy.

Many researchers have analyzed Ca isotopes in biogenic and inorganic calcium carbonates, with the first objective being to evaluate them as a potential new paleothermometer. They have found a small but resolvable temperature dependence of Ca isotope fractionation (e.g., Gussone et al., 2009). Strontium is important minor element in CaCO<sub>3</sub>, and in inorganic aragonite and cultured hermatypic corals, it displays similar isotope fractionation mechanisms to those of Ca (Fietzke and Eisenhauer, 2006). Previous studies have reported some steeper temperature dependence (slopes) in Ca and Sr isotope fractionation of biogenic CaCO<sub>3</sub> and the differences in temperature slopes are interpreted as a large kinetic isotopic effects depending on how fast the crystal growing rate and relative mass difference (rmd) among isotopes. Growth effects on Mg isotope are expected to be highly concerned since Mg/Ca is known to clearly dependent on growth rates (Inoue et al., 2007).

In this study, we performed high-precision Mg isotope measurements in *Porites* coral cultured in thermostated tanks. We here evaluate the plausible factors controlling Mg isotope fractionation in coral CaCO<sub>3</sub> skeletons and present the relationships between Mg isotope values and e.g., water temperature, minor elemental concentrations, growth rates.

キーワード: 造礁サンゴ, マグネシウム同位体, MC-ICP-MS, 飼育実験

Keywords: hermatypic coral, magnesium isotope, MC-ICP-MS, culture experiment

BPT002-13

会場:201B

時間:5月25日 12:15-12:30

## 飼育実験試料を用いたサンゴ骨格気候指標に対する成長速度の影響の評価 Growth-rate influences on coral climate proxies tested by multiple clone culture experiment

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Erika Hayashi<sup>2</sup>, Atsushi Suzuki<sup>1\*</sup>, Toyoho Ishimura<sup>1</sup>, Takashi Nakamura<sup>3</sup>, Akira Iguchi<sup>5</sup>, Kazuhiko Sakai<sup>4</sup>, Akihiro Iwase<sup>4</sup>, Hodaka Kawahata<sup>2</sup>

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While coral-based climate reconstruction has been increasingly reported from many tropical sites, potential ambiguity of oxygen isotope thermometer intrinsic in biomineralization process attracts much attention, including so-called "vital effects", "growth-rate-related kinetic effect", "[CO<sub>3</sub><sup>2-</sup>] effect" and so on. Here we study growth-rate influences on skeletal oxygen and carbon isotope ratios based on a long-term culture experiment using *Porites australiensis* clone colonies. The oxygen isotope ratios of colonies showed negligible influence of growth rate over a large variation (2 - 10 mm yr<sup>-1</sup>) based on the comparison of the seasonal minimum oxygen isotope values during summer. Intercolony variation in the winter extremes can be attributed to growth slowdown / cessation during the cold months. Positive shift in carbon isotope ratios for slower-growing corals was found, and it can be attributed to a kinetic behavior of calcification reaction. Seasonal fluctuation pattern in carbon isotope ratios did not correspond to light intensity. These lines warrant the signal recording ability of coral skeletal oxygen isotope ratios from a long-lived colony of clonal growth as paleo-climate archives, and pose implication for the proper interplication of carbon isotope ratio records.

Keywords: coral, oxygen isotope ratio, Sr/Ca ratio, skeleton

BPT002-14

会場:201B

時間:5月25日 12:30-12:45

## 造礁性サンゴ骨格の窒素同位体比：熱帯・亜熱帯海洋における栄養塩窒素の新指標 Nitrogen isotope of coral skeletons: A new proxy for nitrogenous nutrients in subtropical and tropical ocean

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Atsuko Yamazaki<sup>1\*</sup>, Tsuyoshi Watanabe<sup>1</sup>, Urumu Tsunogai<sup>1</sup>

<sup>1</sup>北海道大・理

<sup>1</sup>Hokkaido University

Coral skeleton could be a high resolution recorder of past nutrient dynamics in tropical and subtropical ocean with decades to millennia time scales. Nitrogen isotope of organic matter in the coral skeleton could vary with that of nitrogenous sources and be a potential to capture nitrogen isotope changes in marine nitrate. However, nitrogen isotope of coral skeletons had problems to be a paleoenvironmental proxy. Reef corals uptake various nitrogen compounds such as (1) dissolved inorganic nitrogen (DIN) assimilated by zooxanthellae, (2) coral consumption of particle and dissolved organic nitrogen (PON, DON), and (3) nitrogen fixation of symbiotic cyanobacteria. In this study, we developed a new method for coral nitrogen isotope analysis and demonstrated which nitrogen sources controlled nitrogen isotope in coral skeletons. For nitrogen isotope analysis of coral skeletons, each 28 mg powder samples were decalcified. Then, all of organic matter in coral skeleton resolved to nitrate and converted into nitrous oxide to introduce into continuous-flow isotope ratio mass spectrometry. The standard deviation of sample measurements was less than 0.2 permil (1sigma). We compared distribution of coral nitrogen isotope with that of nitrate nitrogen isotope in Shiraho coral reef, Ishigaki Island. We sampled the coral cores from five coral colonies distributed from the mouth of Todoroki River that flow into the coral reef to the reef edge. Seawater samples for nitrate were taken at 50 m intervals along the parallel line of coral sampling. Distribution of coral nitrogen isotope was decreasing from +8.6 permil to +3.0 permil toward off-shore. Nitrogen isotope of nitrate was also decrease from +9.0 permil at river mouth to +2.3 permil at reef edge, which showed similar trends with coral nitrogen isotope. Nitrogen isotope of nitrate near the river mouth was originated from nitrate in river water (nitrogen isotope: +8.2 permil). This result suggested that nitrogen source for reef corals was mainly DIN in reef water, and coral skeleton recorded nitrogen isotope of nitrate. Time series of coral nitrogen isotope has a possibility to reconstruct seasonal to interannual variations of nitrate sources to coral reef such as land-derived nitrogen, nitrogen fixation, and upwelled nitrate. In this presentation, we also introduce application examples of a nitrogen isotope proxy to corals alive in coastal reef and open ocean.

キーワード: 造礁性サンゴ骨格, 窒素同位体比, 硝酸, 陸起源物質の供給, 窒素固定, 湧昇

Keywords: coral skeleton, nitrogen isotope, nitrate, terrestrial input, nitrogen fixation, upwelling

BPT002-P01

会場:コンベンションホール

時間:5月25日 14:00-16:30

## Sources of plutonium to the tropical Northwest Pacific Ocean since the mid-20th century: a natural coral archive

### Sources of plutonium to the tropical Northwest Pacific Ocean since the mid-20th century: a natural coral archive

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The main source of plutonium (Pu) to the Pacific Ocean is fallout from atmospheric nuclear weapons testing between 1945 and 1980. Other sources (e.g. discharges from the nuclear industry, radioactive waste dumping and burn-up of nuclear powered satellites) have only made a relatively minor impact. Between 1945 and 1980, 543 atmospheric weapons tests were carried out worldwide with an estimated total released fission energy yield of 189 Mt (UNSCEAR, 2000). Due to the well-defined spatial and temporal inputs of Pu and its physical and chemical properties, Pu can be used a tracer for various oceanic processes such as water mass transport, particle fluxes and scavenging (Lindahl et al., 2010 Mar. Environ. Res.). Massive Porites corals, living in tropical/subtropical shallow waters, have annually-banded aragonite skeletons with high- and low-density increments and grow rapidly, which can provide chronological control and allow high-resolution sampling. Because of such benefits, geochemical composition in coral skeletons has been most widely used as paleoclimate proxies for temperature and chemical composition of seawater in many studies. Plutonium is incorporated in the coral skeleton during growth with a constant relationship between Pu in the coral and Pu in the surrounding seawater. Therefore, the historical Pu signal in the surrounding seawater can be reconstructed by analyzing well-dated coral cores

Here we determine the total Pu activity concentrations and Pu atom ratios in the annual growth bands of an accurately dated modern coral core from Guam Island using multi collector inductively coupled plasma mass spectrometry (MC-ICP-MS) to reconstruct the 1943-1999 Pu records in the tropical Northwest Pacific (Lindahl et al., 2011 Geochim. Cosmochim. Acta). The coral chronology was established in previous works (Asami et al., 2004 Palaeogeogr. Palaeoclimatol. Palaeoecol.; 2005 J. Geophys. Res.), in which coral  $\delta^{18}O$  was determined with high-temporal resolution (biweekly to monthly) over the period 1787-2000. Dating of the coral was based on visual observations of soft X-radiograph images, which showed well-developed annual high- and low-density skeletal growth bandings. Selections relating to annual skeletal growth increments (approximately from January to December) were then assigned. The Pu atom ratios in the coral bands were used to distinguish the source(s) of Pu contamination and characterize the isotopic input from notable nuclear tests. Close-in fallout from the former US Pacific Proving Grounds (PPG) in the Marshall Islands and global fallout were identified as the two main sources. The Guam site was dominated by PPG close-in fallout in the 1950s. In addition, a higher Pu atom ratio was observed that could be attributed to fallout from the Ivy Mike thermonuclear detonation in 1952. The atom ratio decreased in the 1960s and 1970s due to increase in the global fallout with a low Pu atom ratio. Recent coral bands (1981-1999) are dominated by the transport of remobilized Pu, with high Pu atom ratios, from the Marshall Islands to Guam Island along the North Equatorial Current. This remobilized Pu was estimated to comprise 69% of the total Pu in the recent coral bands, although its contribution was variable over time.

Keywords: coral skeleton, annually-dated bands, plutonium, tropical Pacific Ocean, nuclear weapons test, North Equatorial Current

BPT002-P02

会場:コンベンションホール

時間:5月25日 14:00-16:30

## 飼育サンゴ骨格の成長量とそのCa<sup>2+</sup>-ATPase発現の変動に関する研究 Variation of expression of Ca<sup>2+</sup>-ATPase and skeletal growth of cultured corals (*Porites australiensis*)

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Trace elements, such as Sr/Ca and Mg/Ca ratios, of coral skeleton is a commonly used for reconstructing paleoenvironment, especially it has been used to estimate past sea surface temperatures. However the processes controlling trace elements incorporation in coral aragonite are poorly understood and recently it has been reported that skeletal growth might be altered variation of trace element rather than temperature. In zooxanthellate corals, Ca<sup>2+</sup> is transported transcellularly to the calcification site by both calcium channels and by the carrier protein Ca<sup>2+</sup>-ATPase. The pump enzyme Ca<sup>2+</sup>-ATPase has a higher affinity for Ca<sup>2+</sup> than for Sr<sup>2+</sup>, and the Ca<sup>2+</sup>-ATPase pump is activated by exposure of the polyp to light, suggesting that the skeletal Sr/Ca of rapid calcifiers might be lower than that of slow calcifiers because of differences in the Sr/Ca ratio in the bulk calcifying solution. However, there has been no study investigating the relationship between Ca<sup>2+</sup>-ATPase and Sr/Ca and Mg/Ca in the skeleton of *Porites* coral which is dominantly used for the study on paleoclimate. In this study, *Porites australiensis* were cultured under controlled temperature and pH settings and expression level of Ca<sup>2+</sup>-ATPase in each cultured corals was estimated. Also Sr/Ca and Mg/Ca ratios in the same coral colony were analyzed. We will discuss the relationship between skeletal growth rate and expression of Ca<sup>2+</sup>-ATPase.

Keywords: coral skeleton, Ca<sup>2+</sup>-ATPase, growth rate, culture



## 淡水二枚貝イケチョウガイ (*Hyriopsis* sp.) の微量元素比および炭素同位体比の変動要因

### Biological controls on Sr/Ca, Ba/Ca and Carbon isotope in freshwater pearl mussel *Hyriopsis* sp.

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二枚貝類は、低緯度から高緯度、海域・淡水域と様々な環境に生息している生物であり、幅広い古環境の復元に利用できる期待されている。炭酸塩殻 (CaCO<sub>3</sub>) の炭素同位体比 (<sup>13</sup>C<sub>SHELL</sub>) は周囲の溶存無機炭素 (DIC) の炭素同位体比 (<sup>13</sup>C<sub>DIC</sub>) と呼吸などの代謝活動に影響を受けると考えられている (McConnaughey et al., 1997)。そのため、河川水や湖水中の炭素の起源をたどる手がかりとして期待されるが、代謝の影響が一定でないなど、解釈が複雑なことがある。また、CaCO<sub>3</sub> 中の微量元素について、サンゴ類や有孔虫において取り込みに明確な温度依存性があることが知られており、二枚貝類においても古環境復元のツールとして期待されている。しかし、二枚貝類の微量元素についての研究は数が少なく、特に淡水棲二枚貝についての研究はほとんど行われていない。本研究では、霞ヶ浦で商業的に養殖されている淡水真珠二枚貝イケチョウガイ (*Hyriopsis* sp.) の酸素・炭素同位体比および微量元素比について分析を行い、(1) <sup>13</sup>C<sub>SHELL</sub> の変動要因、(2) 炭酸塩殻中の微量元素比の変動に影響を与える要因について検討を行った。

本研究では、3 個体 (試料番号: KGU-01, 11, 12) の貝殻を材料として、酸素・炭素同位体比および、KGU-01, 11, 12 の微量元素比 (Sr/Ca 比, Ba/Ca 比) について分析を行った。また、湖水を月に 1 度採水し、ろ過した後にその Mg, Ca, Sr, Ba 濃度および、酸素・炭素同位体比を分析した。

#### ・ <sup>13</sup>C<sub>SHELL</sub> の変動要因

周囲の水の <sup>13</sup>C<sub>DIC</sub> は、冬から夏にかけて -8.62 から -14.63 ‰ と変化した。一方、<sup>13</sup>C<sub>SHELL</sub> は約 -9 から -12 ‰ の間で変動したが、周期性などの特徴は示さなかった。<sup>13</sup>C<sub>DIC</sub> と呼吸の炭素同位体比 (<sup>18</sup>O<sub>RESP</sub>) の <sup>13</sup>C<sub>SHELL</sub> への寄与は McConnaughey et al. (1997) の式によって計算できる。<sup>13</sup>C<sub>RESP</sub> の値が周囲の堆積物の <sup>13</sup>C の一致し、寄与率が一般的な 10 ‰ と仮定すると、計算される <sup>13</sup>C<sub>SHELL</sub> は分析した値よりも -2.5 ‰ ほど低い値となった。一方、<sup>13</sup>C<sub>RESP</sub> を考慮せず、<sup>13</sup>C<sub>SHELL</sub> が <sup>13</sup>C<sub>DIC</sub> と平衡であると仮定すると、計算結果と分析結果はほぼ一致した。このことより、イケチョウガイの <sup>13</sup>C に強く影響を与えている要因は <sup>13</sup>C<sub>RESP</sub> でなく、<sup>13</sup>C<sub>DIC</sub> であると考えられる。

#### ・ 炭酸塩殻中への微量元素の取り込み

炭酸塩殻の Sr/Ca 比, Ba/Ca 比は <sup>18</sup>O<sub>SHELL</sub> と負の相関で周期的な変動を見せた。一般に CaCO<sub>3</sub> の Sr と Ca の置換は熱力学的分配、もしくは速度論的分配に従う。もし、Sr の取り込みが熱力学的分配に従うならば、Sr/Ca 比は水温と負の相関を示す。しかし、本研究では Sr/Ca 比は <sup>18</sup>O<sub>SHELL</sub> と負の相関、すなわち水温と正の相関を示した。これより、イケチョウガイの炭酸殻の Sr/Ca 比は熱力学的な要因ではなく、速度論に依存していると考えられる。イケチョウガイは、成長速度の速い夏場にかけて Sr/Ca 比が増加し、また成長速度 (mm/yr) と Sr/Ca 比 (年平均) の間に正相関が見られた。したがって、Sr/Ca 比の成長速度による影響は海水二枚貝だけでなく、淡水二枚貝にも言えることであると考えられる。

一方、生物の作る炭酸塩殻中の Ba 濃度は、一般に周囲の水の Ba 濃度に依存すると言われている。しかし、前述したように、湖水の Ba/Ca 比は規則的な変動を示していない。したがって、イケチョウガイの Ba/Ca 比は周囲の水の Ba/Ca 比の影響を受けていない。また、<sup>18</sup>O<sub>SHELL</sub> と負の相関を示したことより、Sr/Ca 比と同様に熱力学的な要因ではなく、成長速度に依存していると考えられる。

\*McConnaughey, T. A., J. Burdett, J. F. Whelan, and K. P. Charles (1997), Carbon isotope in biological carbonates: Respiration and photosynthesis, *Geochim. Cosmochim. Acta*, 61, 611-622.

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