

New evidence for halite co-precipitation during coral calcification

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In the last JpGU Meeting, we reported halite grains in coral skeleton through the observation of massive coral skeleton of *Porites lobata* by Analysis Transmission Electron Microscope (ATEM). Each halite grain typically shows a square shape and its grain size is around 80 nm. The spatial distribution of halite grains is inhomogeneous and seems to be independent on the arrangement of growth lines.

We observed new evidence that the halite grains in coral skeleton could precipitate during coral calcification. The electron diffraction patterns from some selected areas including both an aragonite and a halite grain show that there are special crystallographic orientation relationships between them. In consideration of misfit ratios between some selective bond lengths of halite and those of aragonite, crystallographic orientations of halite and aragonite seem to be a kind of hetero-epitaxial relationship.

This is the first observation for a primary precipitated mineral phase other than aragonite in coral skeletons. The halite phase in coral skeleton will provide a new perception for understanding the process of coral calcification.

Keywords: reef-building coral, calcification, biomineral, aragonite

Ocean acidification in the tropical Northwest Pacific since the mid-20th century reconstructed from coral boron isotope

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Ocean acidification has been accelerating as a result of absorption of increasing anthropogenic CO₂ in the atmosphere emitted by fossil-fuel combustion and land-use practices since the Industrial Revolution, which can be resulting in decreased surface ocean pH and posing a critical threat to marine ecosystems (e.g., Sabine et al., 2004; Orr et al., 2005). By the end of the 21st century, predictions based on different scenarios indicate that ocean pH will decrease by 0.3-0.4 pH units. Only a few long-term continuous observations of sea surface pH have been derived from Station ALOHA off the Hawaiian Islands in the North Pacific, near the Bermuda Islands, and near the Canary Islands in the North Atlantic. A decreasing pH trend in the western North Pacific surface waters for 1983-2007 was estimated from the observational data of oceanic CO₂ partial pressure and related properties (Midorikawa et al., 2010). To elucidate the natural variability of ocean pH and assess the actual trend in ocean acidification more accurately, we must go further back in time. For these reasons, we rely on paleo-pH archives or other related parameters.

Massive corals, an informative archive of past ocean environments, precipitate annually banded calcium carbonate skeletons at a relatively rapid rate (about 1 cm per year), allowing for accurate chronological control and high-resolution sampling. Because of pH-dependent isotopic fractionation between the two dominant boron species in seawater, boron-isotopic systematics in marine carbonates provide a potential proxy for ocean pH in the past (e.g., Hemming and Hanson, 1992). Nevertheless, only two previous investigations provided boron-isotope time series from long-lived corals from the Great Barrier Reef in the South Pacific for the last 300 years. Unlike seawater temperature and salinity records (Asami et al., 2005; Felis et al., 2009), no coral-based reconstruction of long-term pH variation in the North Pacific has been reported.

Here, we generated an annually resolved 60-year-long (1940-1999 A.D.) record of seawater pH from boron isotope composition in a *Porites* coral collected in Guam Island, located in the Western Pacific Warm Pool which contains the highest annual sea surface waters and serves as a heat engine for the earth climate. The first long-term continuous boron isotope-pH proxy record in the North Pacific from the coral provides evidence of a slight ocean acidification trend (equivalent to 0.05-0.08 pH units for surface water) since the mid-20th century, although the critical factors that affect interannual variability remain unknown (Shinjo et al., 2013). From this perspective, the results of this study will provide improved constraints on global atmosphere-ocean interaction models and understanding of the future coral reef ecosystems.

Keywords: coral skeleton, boron isotope composition, pH, ocean acidification, North Pacific

15N/14N mapping of the isotope labeling cultured foraminifera using ultra thin section

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Shallow water benthic foraminifera, *Ammonia beccarii*, survive under anoxic conditions in conjunction with possible endobionts. Based on the amino acid analysis, those endobionts are expected to utilize nitrate pool in the foraminifera. However, nitrogen cycles in the foraminiferal cell and endobionts are still unclear. Here, we obtained two dimensional-nitrogen isotopic compositions of *A. beccarii* which had been incubated under oxic and anoxic conditions with ¹⁵N-labeled nitrate. After observing with transmission electron microscope to confirm cellular ultrastructure and endobiont distribution, same ultra thin section was examined for nitrogen isotopic composition analysis using secondary ion mass spectrometer. Nitrogen isotopic compositions were measured with spatial resolution better than 400 nm. ¹⁵N-enriched parts were found in certain structures in the cell, but not in the endobionts in this experiment.

Keywords: Benthic foraminifera, nitrate respiration, symbiotic microbe, NanoSIMS