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Tropical Northwest Pacific pH Variability Inferred from Boron Isotope Composition in Annually-banded Coral Skeleton

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Ocean acidification has been accelerated due to adsorption of increasing anthropogenic carbon dioxide emissions from the atmosphere since the Industrial Revolution [Intergovernmental Panel on Climate Change, 2007], probably causing a serious decrease in surface ocean pH in the future [Zeebe et al., 2008 Science]. This issue may bring critical threat to calcifying organisms and coral reef ecosystems [e.g., Orr et al., 2005 Nature]. Our current knowledge of ocean acidification is mainly the result of model simulation studies [e.g., Cao and Caldeira, 2008 Geophys. Res. Lett.]. In the Pacific Ocean, a continuous observation of sea surface pH has been conducted only at the offshore site of Hawaii (Hawaii Ocean Time-series: HOT), which shows a decrease trend of seawater pH during the last 2 decades, in accordance with an increase in surface water partial pressure of carbon dioxide followed by the atmospheric carbon dioxide rise [Takahashi et al., 2006 J. Geophys. Res.]. However, the actual long-term trend and variability of seawater pH for the last several centuries remains unknown.

Massive Porites sp. corals, one of the most informative archive for past ocean environments, precipitate annually-banded aragonite skeletons and grow rapidly, which can allow accurate chronological control and high-resolution sampling. Due to isotopic fractionation between the two dominant boron species in seawater, boron isotopic systematics in marine carbonates provides a potential proxy for pH of ancient oceans [e.g., Hemming and Hanson, 1992 Geochim. Cosmochim. Acta]. Up to now, there are a few studies conducting reconstruction of seawater pH using boron isotopic composition of modern and fossil corals. Only the two previous studies [Pelejero et al., 2005 Science; Wei et al., 2009 Geochim. Cosmochim. Acta] reported boron isotope composition time series of long-lived Porites corals from the Great Barrier Reef that showed significant paleo-pH variability at sea surface in the southwestern Pacific Ocean for the last 300 years. Nevertheless, unlike seawater temperature and salinity records, no coral-based reconstruction of long-term pH variability in the North Pacific Ocean has been reported yet. To better understand natural variability of the ocean pH and predict its future trend more accurately, long time series of pH proxy records during periods before the instrumental data accumulation are needed.

Here, we present annually resolved boron isotope composition time series of a modern Porites coral from Guam and reconstruct interannual variability and trend of sea surface water pH in the tropical northwest Pacific Ocean since 1940. The pattern of reconstructed time series for Guam coral is significantly different from those reconstructed from the Great Barrier Reef corals, which appears to reflect regional variability on response to ocean acidification together with the El Nino events-associated fluctuation.

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