

Paleoenvironmental analysis using Tridacnidae shells from archaeological sites in Okinawa-jima, subtropical southwestern

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Symbiont-bearing Tridacnidae giant clams living in shallow waters of the Indo-Pacific tropical and subtropical regions can be used as an archive for documenting high-resolution record of thermal and hydrologic variations in coral reef environments for the past. Their shells, composed of dense aragonitic increments, are less sensitive to diagenetic alteration than porous skeleton of corals. They have annually and daily banded shells structure, providing chronological controls (e.g., Bonham 1965). The oxygen isotope composition ($\delta^{18}\text{O}$) of shells, which are precipitated isotopically equilibrium with seawater, can reflect the temperature and seawater $\delta^{18}\text{O}$ (e.g., Aharon & Chappell 1986). Several studies on paleoenvironmental reconstructions around the Ryukyu Islands were performed using geochemistry in fossil corals from Okinawa-jima (Mitsuguchi et al. 1998), Yonaguni-jima (Suzuki et al. 2001), Kikai-jima (Morimoto et al. 2007), and Kume-jima (Seki et al. 2012). However, only a $\delta^{18}\text{O}$ record has been published from 6.2 ka giant clams from Kume-jima (Watanabe et al. 2004).

Here we present seasonally resolved $\delta^{18}\text{O}$ time series of fossil Tridacnidae shells recovered from two archaeological sites (the Kogachibaru Shell Mound and the Second Aragusuku-Shichabaru Ruin) in Okinawa-jima, southwestern Japan to reconstruct subtropical coral reef environments of the past. The samples, mainly composed of aragonite shells with limited amounts of calcite cements, were selected for geochemical analyses. The radiocarbon dating results indicated that they lived during the early and middle Shell Mound periods in Okinawa-jima, corresponding to the middle-to-late Holocene, which is in good agreement with ages inferred from excavation (Okinawa Prefectural Board of Education 1987; Okinawa Prefectural Archaeological Center 2006). The shell $\delta^{18}\text{O}$ values roughly showed seasonal variations, coincident with the occurrence of annual growth bands. The averages of annual, summer, and winter $\delta^{18}\text{O}$ values of fossil shells were significantly lower than aragonite theoretically precipitated in present-day coral reef water of Okinawa-jima. These results demonstrate that the seawater temperature was higher and/or salinity was lower at the sites than today. It is likely that the giant clams lived in relatively small and/or closed coral-reef lagoons with less water circulation where seawater is highly susceptible to insolation-induced temperature increase and input of fresh water; the effect could be enhanced by the fisheries lifestyle that stonewalling would be constructed at shallow waters through the use of tidal variation during the Shell Mound period in Okinawa-jima.

Although it is extremely difficult to find well-preserved fossil Tridacnidae shells from carbonate sediments that are not fragmented, archaeological ruins and shell mounds can yield many fossils. Results of our study suggest that the use of fossil shells from archaeological sites can enable the reconstruction of temporal and spatial variations in coral reef environments and of the history of lifestyles and culture during prehistoric and protohistoric ages.

Keywords: coral reef, Tridacnidae, shells, fossil, oxygen isotopic composition, archaeological site