ENVIRONMENTAL SIGNIFICANCE OF CARBON AND OXYGEN ISOTOPE RATIOS OF Banded Corals FROM LAKSHADWEEP, INDIA

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The stable isotope ratios (δ18O and δ13C) of the coral Porites compressa from the Lakshadweep islands, eastern Arabian Sea, preserve environmental parameters related to monsoon-induced upwelling. The oxygen isotopic ratios in P. compressa record the seasonal drop in sea surface temperature (SST) during the monsoon season. An earlier calibration of the coralline δ18O with observed changes in SST is used to estimate past SST changes and to evaluate the relationship with upwelling and rainfall. The seasonal variations in carbon isotope ratios seem to be controlled by photosynthesis of the algal symbiont, which in turn is modulated by monsoon activities; sedimentation, sediment suspension, water current and turbidity. Both δ18O and δ13C in this species do reflect the monsoon clearly. Copyright © 1996 INQUA/Elsevier Science Ltd

INTRODUCTION

The Earth’s climate has changed in the past, both on short and on long time scales. Reconstruction of past climates provides a snap shot of prevailing environmental conditions and a tool to test climate models. The availability of instrumental records of climate are limited to the past several decades at isolated sites, such as SST in the Indian seas. Hence, for a better understanding of natural climate variability it is necessary to extend the instrumental climate records in space and time, using various natural archives as proxy indicators of climate. Long lived hermatypic corals preserve high quality, high resolution records of ‘ocean climate’ of the past few centuries. The study of isotopic and chemical tracers in the annual bands of corals has been shown to provide accurate records of seasonal and interannual variability of meteorological and oceanographic parameters such as the sea surface temperature (SST), salinity, upwelling and rainfall (Fairbanks and Dodge, 1979; Dunbar and Wellington, 1981; Druffel, 1985; Patzold, 1984; McConnaughey, 1989a, b; Shen et al., 1987, 1992; Cole and Fairbanks, 1990). We have undertaken a study of corals from Lakshadweep Islands to evaluate their paleoclimatic potential.

Indian Corals: A Proxy Record of Monsoonal Activity

We first summarize earlier work on corals in Lakshadweep region (Fig. 1). The South Asian summer monsoon (June–September) induces mixing of the surface waters of the Arabian Sea leading to a reduction in SST of about 3–4°C. This reduction is recorded in the annual bands of Porites corals growing in the Lakshadweep regions (10–13°N, 70–73°E) (Chakraborty and Ramesh, 1992). In order to use coralline δ18O as a proxy for SST it is first essential to calibrate the oxygen isotope ratio of coral CaCO3 with the observed SST variations. To translate the δ18O time series in the coral CaCO3 to SST it is necessary to quantitatively assess the isotope disequilibrium offset since corals do not precipitate CaCO3 in equilibrium with seawater (Weber, 1974; Weber and Woodhead, 1972; Swart, 1983). Complex biological processes, such as metabolism and endosymbiotic photosynthesis, result in metabolic and/or kinetic fractionation. These processes deplete the isotope composition (i.e. ratio of heavy to light isotopes) of coral CaCO3 relative to that expected for equilibrium precipitation. This 'disequilibrium offset' can be determined by comparing the coralline isotope ratios with the giant clam Tridacna maxima (Chakraborty and Ramesh, 1993), which is believed to precipitate CaCO3 in isotopic equilibrium (Aharon and Chappel, 1986; Romanek and Grossman, 1989).

Following this concept the disequilibrium offset in P. compressa was estimated. Amini and other lagoons in the Lakshadweep archipelago are enclosed by coral reefs, but are well connected to the open sea through various openings (Chakraborty and Ramesh, 1992). The lagoons are generally shallow. For instance the mean depth of the Kavaratti lagoon is 3.5 m at high water (Suresh and Mathew, 1993). In the absence of detailed temperature records for each of these lagoons, we assume that they have similar temperature variations. The seasonal temperature variation of the Kavaratti lagoon is 27.5°C to 31.6°C (two years data; Suresh and Mathew, 1993). These variations closely resemble the adjoining open ocean SST variations, though the absolute values are slightly higher than the open ocean SST (26.5–30.5°C, Comprehensive Ocean Atmospheric Data Set (COADS) data).

A coral (P. compressa) and a giant clam (T. maxima) grew within a metre in the Amini lagoon (11°07'N, 72°44'E). The samples were collected during December 1988. The annual bands were viewed using an X-ray photograph. In case of the giant clam, the yearly