Southern oscillation-related variations in rainfall recorded in the stable oxygen isotopic composition of living and fossil massive corals in Papua New Guinea

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Introduction

Along the north coast of Papua New Guinea, inter-annual variations in rainfall are strongly linked to the Southern Oscillation (McGregor, 1992). The region experiences relative drought during the El Niño phase, and particularly heavy rainfall during the La Niña phase. The area around Madang (latitude 5° 9′ S, longitude 145° 48′ E) has abundant rainfall (*c.* 3000 mm/year) which is isotopically light in oxygen (*c.* −7.88‰ $\delta^{18}O_{SMOW}$; Yurtsever and Gat, 1981). These factors, coupled with the relatively small intra- and inter-annual variations in SST, give rise to the possibility of extracting records of past rainfall from the isotopic analysis of annually-banded massive corals from the coastal waters. We are using this rationale in an attempt to reconstruct variability in SO-related rainfall in PNG over the past 2000 years, and this report presents results from the first stage of a 3-year project.

Methods

Cores (up to 3m length) were collected from living and fossil massive Porites corals in the vicinity of Madang. These were sub-sampled for subsequent isotopic analysis at a sampling density of either 4 samples/annual growth increment or 6 samples/annual growth increment. Annual growth increments were identified on the basis of distinctive fluorescent banding in the skeleton (Isdale, 1984) and subsequently confirmed by reference to a seasonal $\delta^{13}C$ signal in the skeletal carbonate. Stable isotope analyses were performed on a VG Prism mass spectrometer with automatic carbonate preparation system. Between-run reproducibility over the entire period of the analyses (ascertained by running a coral powder standard as samples on each run) was 0.097‰ in $\delta^{18}O$ and 0.068‰ in $\delta^{13}C$ (1 standard deviation; n = 92). Preliminary dating of fossil cores was achieved by alpha spectrometry.

Results and discussion

A seventy year record of skeletal $\delta^{18}O$ from a living Porites coral near Madang is presented in Figure 1, along with plots of rainfall at Madang and Wright's Southern Oscillation Index (SOI). The following summarises some of the key features of the record:

a) There is a strong correlation between coral skeletal $\delta^{18}O$ and both Madang rainfall and Wright's SOI (confirmed by simple linear regression and by cross spectral analysis). b) For the period from the mid 1950's through until date of collection (1991) there is a strong 3.8-year Southern Oscillation periodicity to the stable isotope data, but in the earlier part of the record (1920's-1940's) the *c.* 4-year periodicity is less prominent, and there is some indication of a quasi-biennial periodicity (confirmed by spectral analysis). c) There is an overall trend towards lighter isotopic values through our record. This trend could reflect a warming of SST of about 1°C, an increase in rainfall through time, a change in isotopic composition of rain water, changing vital effects in the coral or some combination of these. Assessment of incomplete meteorological records back to 1916 does not support an increase in rainfall through time, and analysis of multiple cores through the same coral and of cores from adjacent and nearby corals indicate that vital

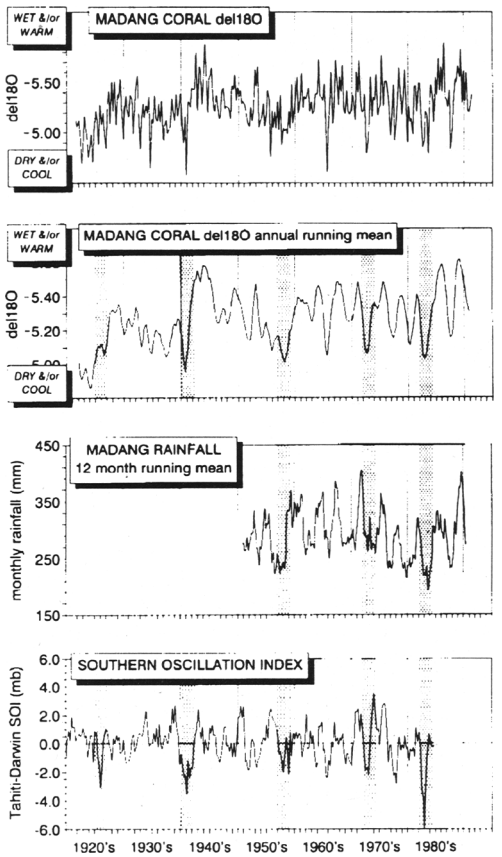

FIG. 1. The stable oxygen isotope composition of a massive *Porites* coral from Madang plotted with local rainfall and Wright's Southern Oscillation Index. The unsmoothed oxygen record (corrected to PDB) is plotted in the top panel. The coral was subsampled into *c.* 3-month growth increments. In the second panel the effects of seasonality have been removed from the data by plotting an annual (4 sample) running mean. The third panel displays a plot of local rainfall, again smoothed by an annual running mean. The fourth, lower, panel presents Wright's SOI. Widely recognised severe El Niño events are picked out in stipple shading.

effects are relatively constant. Therefore, we suggest that a warming of SST is the most likely cause of the trend in $\delta^{18}O$.

Preliminary results from the analysis of 2 fossil corals (*c.* 1880 years B.P. and 2490 years B.P.) indicate the presence of a palaeo Southern Oscillation, and confirm the potential of using massive corals for extending proxy records of SO activity back into the Holocene.

Acknowledgements

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References

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