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Geochronologic methods for dating coral microatolls in the Philippines

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Coral microatolls allow for the reconstruction of relative sea level (RSL) and the inference of tectonic deformation along tropical coastlines over the Holocene. Microatolls track RSL with unparalleled vertical precision, and their annual banding allows us to count years precisely over an individual coral's lifetime; however, RSL histories reconstructed from multiple corals depend on accurate and precise radiocarbon (¹⁴C) or uranium-thorium (²³⁰Th) ages.

We collected coral microatoll slabs from sites in Ilocos Region, northwestern Luzon, Philippines, and dated them with ¹⁴C and ²³⁰Th techniques. Notably, initial RSL reconstructions for some sites disagreed markedly depending on the dating technique used. Attempts to replicate geochronologic analyses have shown that the coral skeletons are susceptible to diagenesis, complicating efforts to accurately determine coral ages.

We are developing a strategy to overcome this limitation. We extracted multiple samples from each microatoll slab for paired ¹⁴C and ²³⁰Th dating. The number of annual bands separating any dated sample was used to further constrain the age of the coral; by subtracting the number of years from each dated sample, samples taken from different parts of the slab can produce independent estimates of the outermost preserved band. After excluding anomalously young replicate ¹⁴C ages and samples flagged as partly calcified by x-ray diffraction, we find that ²³⁰Th ages from a single coral disagree at 4σ in 4 of 8 cases, whereas calibrated ¹⁴C dates overlap at 2σ in 8 of 9 cases for an arbitrary radiocarbon marine reservoir correction, ΔR = 0 yr.

Using OxCal and the Marine20 calibration curve, we apply Bayesian statistics to combine ¹⁴C and ²³⁰Th ages, to estimate ΔR, and to determine the coral ages using the best available data. We further analyze the ΔR value for each coral, and account for overdispersion and underdispersion,

whilst generating a ΔR value per site, and an overall ΔR value (inclusive of all sites). We find no statistically significant difference in ΔR for each site, and we calculate an overall ΔR of -155 ± 117 yr for sites in Ilocos Region since the mid-Holocene, though century-scale variability in ΔR may occur.

Additionally, to improve the reliability of our dates, our final dating strategy in OxCal is to apply the previously determined ΔR , to a code that places the corals in sequence (based on precise elevation measurements, morphological similarities, and coral die-down events), along with the ^{14}C dates that are dated to the outermost preserved band.