Calculating paleotemperatures from the elemental composition of coral skeleton: A new approach to old proxies

GLENN A GAETANI AND ANNE L. COHEN

Dept. Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole MA 02543 USA

Paleoceanographic records are typically derived from biogenic carbonates using empirical relationships between elemental ratios and environmental variables. These relationships are calibrated using the skeletons of living organisms grown under known conditions. While this approach has produced significant advances in paleoclimatology, its accuracy is limited because the compositional signal in biogenic carbonates is driven by a combination of factors, rather than a single environmental variable. We have developed a new approach to deriving paleotemperature estimates from coral skeletons through knowledge of their Mg/Ca, Sr/Ca and Ba/Ca ratios. Using experimentally determined partition coefficients for Mg, Ca, Sr, and Ba between abiogenic aragonite and seawater [1] combined with a Rayleigh fractionation model for the precipitation of aragonite from a calcifying fluid, the temperature at which the aragonite was precipitated can be explicitly calculated.

When aragonite precipitates from seawater, it's composition is determined both by aragonite-seawater partition coefficients and the mass fraction of aragonite precipitated from the calcifying fluid. For a given amount of aragonite precipitated, the Sr/Ca, Ba/Ca and Mg/Ca ratios decrease with increasing temperature. Conversely, at a given temperature, the Sr/Ca and Ba/Ca ratios decrease while the Mg/Ca ratio increases as the amount of aragonite precipitated from a given mass of fluid increases. The combination of these effects reproduces the compositional variability found in the aragonite skeletons of Scleractinian corals. Therefore, the Mg/Ca, Sr/Ca and Ba/Ca ratios of coral skeleton can be described as a Rayleigh fractionation process using three equations and three variables: (1) temperature, (2) fraction of aragonite precipitated, and (3) enrichment/depletion of the calcifying fluid. By combining these three equations, it is possible to explicitly solve for temperature, providing a robust method for deriving proxy paleotemperature records.

References

[1] Gaetani G.A. and Cohen A.L (2006). *GCA* **,** in review