Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.4464

Refining trace metal temperature proxies in cold-water scleractinian and stylasterid corals

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The Li/Mg, Sr/Ca and oxygen isotopic ($\delta^{18}O$) compositions of many marine biogenic carbonates are sensitive to seawater temperature. Corals, as cosmopolitan marine taxa with carbonate skeletons that can be precisely dated, represent ideal hosts for these geochemical proxies. However, efforts to calibrate and refine temperature proxies in cold-water corals (<20°C) remain limited. Here we present skeletal Li/Mg, Sr/Ca, $\delta^{18}O$ and carbon isotope ($\delta^{13}C$) data from live-collected specimens of aragonitic scleractinian corals (*Balanophyllia, Caryophyllia, Desmophyllum, Enallopsammia, Flabellum, Lophelia,* and *Vaughanella*), both aragonitic and high-Mg calcitic stylasterid genera (*Stylaster* and *Errina*), and shallow-water high-Mg calcite crustose coralline algae (*Lithophyllum*, *Hydrolithon*, and *Neogoniolithon*). We interpret these data in conjunction with results from previously explored taxa including aragonitic zooxanthellate scleractinia and foraminifera, and high-Mg calcite octocorals. We show that Li/Mg ratios covary most strongly with seawater temperature, both for aragonitic and high-Mg calcitic taxa, making for reliable and universal seawater temperature proxies. Combining all of our biogenic aragonitic Li/Mg data with previous calibration efforts we report a refined relationship to temperature: $Li/Mg_{All\ Aragonite} = 5.42exp(-0.050\times T(°C)$ (R^2 = 0.97)). This calibration now permits paleo-temperature reconstruction to better than ±3.4°C (95% prediction intervals) across biogenic aragonites, regardless of taxon, from 0 to 30 °C. For taxa in this study, aragonitic stylasterid Li/Mg offers the most robust temperature proxy ($Li/Mg_{Stylasterid(Arag)} = 5.64exp(-0.046\times T$ (°C)) (R^2 = 0.95)) with a reproducibility of ±2.3°C. For the first time, we show that high-Mg calcites have a similar exponential relationship with temperature, but with a lower intercept value ($Li/Mg = 0.63exp(-0.050\times T(°C)$ (R^2 = 0.92)). This calibration opens the possibility of temperature reconstruction using high-Mg calcite corals and coralline algae. The commonality in the relationship between Li/Mg and temperature transcends phylogeny and suggests a similar abiogenic trace metal incorporation mechanism.