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Calibration of Li/Mg paleothermometry in colonial scleractinian cold-water corals: the role of aragonite precipitation rate

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Given past seawater temperature is crucial for understanding ocean circulation and climate linkages, substantial research has focused on the development of geochemical temperature proxies in marine carbonates to extend temperature records beyond the instrumental period. Cold-water corals (CWCs), particularly colonial scleractinian species inhabiting diverse ocean depths and latitudes, form robust aragonite skeletons that can be precisely dated by radiometric methods, thus have the potential to archive continuous decadal variation of its living environment. Among the investigated trace metal and stable isotopic ratios, the Li/Mg ratio in scleractinian corals exhibits a strong relationship with seawater temperature during calcification. However, there are still large uncertainties remain.

In this study, we measured Li/Ca, Mg/Ca, Sr/Ca, B/Ca and U/Ca ratios in both the calyx and stem edge of live-collected colonial CWCs from seawater spanning a range of temperatures. Together with a coral biomineralization model, we aim to elucidate the dominant factors governing Li and Mg incorporation into coral aragonite skeleton and refine the temperature dependence of the Li/Mg proxy. We found that Li/Ca, Mg/Ca, and Li/Mg ratios in the calyx were systematically higher than those in the stem edge. Rather than attributing these differences to the influence of centers of calcification (COCs), we propose other factors contribute, as evidenced by the elevated B/Ca ratio in the calyx. Combined with model simulation results, the higher Li/Ca, Mg/Ca, and B/Ca ratios but lower U/Ca ratios in the calyx than the stem edge of colonial CWCs demonstrate that the calyx may have experienced a higher degree of pH up-regulation compared to the stem edge for colonial CWCs. In addition, model simulations and coral data imply that aragonite precipitation rate is a key factor influencing the Li/Mg ratio, potentially accounting for the scatter observed at the lower temperature range of the calibration. Our study underscores the need for further research to reduce the uncertainty in Li/Mg paleothermometry.