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Isotope and trace element composition of biogenic amorphous calcium carbonate (ACC) formed by cyanobacteria

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Amorphous calcium carbonate (ACC) has been widely studied owing to its importance as a precursor phase to crystalline carbonates in biotic and abiotic systems. While several studies have focused on the structural characterization of ACC, little is understood about the variability of its isotope and trace element composition. Addressing this question is essential because: 1) the isotope and trace element composition of carbonates has been intensively used as a proxy of past environments; 2) the environmental signals recorded in the crystalline carbonates may vary depending on whether they formed directly from the solution or through ACC, which thus could impact the interpretation of carbonate-based geochemical proxies of the past environment; 3) biologically controlled processes could impart unique chemical signatures to the ACC, which in turn could be used to trace the remnants of the biomineralization process in modern and ancient environments.

In this study, the barium (Ba) and strontium (Sr) stable isotope fractionation were studied in the laboratory in cyanobacteria forming intracellular ACC. Our results show that the fractionation factors of Ba and Sr isotopes between cyanobacteria cells and the fluid (the growth medium), i.e., Δ^{137}Ba and Δ^{88}Sr, were equal to –0.25 ‰ and between –0.46 ‰, respectively. Our findings suggest that ACC-forming bacteria could introduce Ba and Sr isotope variability in environmental records and may have important implications for Ba and Sr geochemical cycles, especially in environments where they thrive. Moreover, the direction of Ba and Sr isotope fractionation during ACC formation is consistent with that occurring during the formation of other biogenic carbonates but differs in magnitude, suggesting Δ^{137}Ba and Δ^{88}Sr could potentially be a fingerprint of ACC biomineralization in the fossil rock record. Lastly, we will present ongoing results using synchrotron-based X-ray fluorescence nanoimaging technique to quantify the trace element composition of biogenic ACC formed by cyanobacteria at a single-cell scale, and discuss its implication in the context of carbonate proxies.