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Use of nano-XRF and XANES at the Ca K-edge to assess the influence of amorphous-calcium-carbonate-forming bacteria on calcium and trace element cycling in modern ferruginous environments

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Several taxonomically and environmentally diverse bacteria were shown to form intracellular amorphous calcium carbonate (ACC) biominerals. These bacteria sequester substantial amounts of Ca during ACC formation and are abundant in the environment, suggesting they may represent a significant but underappreciated driver of Ca geochemical cycle. Accordingly, we conducted a field study in Lake Pavin (France), a modern ferruginous lake where sediments are enriched with ACC-forming bacteria, including *Achromatium* (a sulfur-oxidizing gammaproteobacterium) and magnetotactic bacteria (MTB) affiliated with Alphaproteobacteria and Gammaproteobacteria. Several sediment cores (30 cm long) from a water depth of 20 m were collected and sliced anaerobically into 1 cm thick sections over three different field campaigns between 2021-2022. Bulk mineralogy and electron microscopy analysis showed that the ACC-forming bacteria in the sediments were mixed with other Ca-containing phases such as anorthite, and crystalline carbonates. In order to quantify the relative importance of ACC-forming bacteria as a Ca reservoir compared with other Ca-bearing phases, we used X-ray Absorption Near Edge Structure (XANES) spectroscopy at the Ca K-edge. Our results showed that ACC-forming bacteria contribute up to 40% of Ca to total Ca reservoir of Pavin sediments. These findings suggest that ACC-forming bacteria constitute a non-negligible reservoir of Ca in the sediments of this ferruginous lake. Lastly, we will also used synchrotron-based nano-X-ray-fluorescence (s-XRF) spectroscopy to elucidate the chemical composition of ACC-forming bacteria from Lake Pavin at single-cell scale, thereby providing new insights into how these bacteria influence trace element cycles such as barium (Ba) and strontium (Sr). Overall, these findings underscore the capability of synchrotron techniques in resolving the fine-scale geochemistry of ACC-forming bacteria and offer new perspectives on how microbial processes influence Ca and trace element cycling in ferruginous environments.