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# Intracellular formation of amorphous calcium carbonate by bacteria: from molecular actors to environmental impacts

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An increasing number of bacteria forming intracellular amorphous calcium carbonates (iACC) has been evidenced, including diverse Proteobacteria and Cyanobacteria [1-2]. Recently, we identified an unknown gene which serves as a good marker of the capability of cyanobacteria to form iACC [3]. Phylogenetic reconstructions suggest that this gene was present in ancestral cyanobacteria with lossess in various lineages along the evolution of Cyanobacteria. To the date of Feb. 25 2022, we have detected this gene in more than 167 cyanobacterial genomes. Interestingly, a significant number of genomes affiliated to *Microcystis*, a sometimes toxic bloom-forming cyanobacterium, contain this gene (Gaëtan et al., in prep). Consistently, we observed abundant iACC in *Microcystis* cells collected in several natural aqueous environments, suggesting a potentially important environmental impact that will be discussed. Last, we will adress another potential environmental impact of iACC biomineralization, which relates to its peculiarity regarding trace element fractionation. In particular, one iACC-forming cyanobacterium efficiently sequesters the radioactive $^{226}$Ra isotope intracellularly, even from Ra-diluted solutions and in the presence of competing cations such as Ca, Ba and Sr [4]. Using NanoSIMS, we mapped radium at the submicrometer-scale and demonstrated that Ra was sequesterd primarily within iACC and to a lesser degree within polyphosphate inclusions. This may benefit the future development of efficient $^{226}$Ra bioremediation strategies.

[1] Benzerara et al. (2020) The gammaproteobacterium *Achromatium* forms intracellular amophous calcium carbonate and not (crystalline) calcie. Geobiology 19, 199-213.

[2] Monteil CL et al. (2021). Intracellular amorphous Ca-carbonate and magnetite biomineralization by a magnetotactic bacterium affiliated to the Alphaproteobacteria. *ISME J 15, 1-18.*

[3] Benzerara K et al. (2022) A new gene family diagnostic for intracellular biomineralization of amorphous Ca-carbonates by cyanobacteria. *Genome Biology and Evolution*, in press.

[4] Mehta N et al. (2022) Cyanobacteria accumulate radium ($^{226}$Ra) within intracellular amorphous calcium carbonate inclusions. *ACS ES&T Water*, in press.