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Signatures of bacterial weathering detected by statistical characterizations of calcite surface microtopography

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Detecting microtopographic signatures of microbe-mineral interactions is pivotal for modeling the contribution of microorganisms to chemical weathering and uncovering traces of geosphere-biosphere interactions in the geological record [1]. Yet, conventional methods based on qualitative descriptions of etching features supposedly induced by microorganisms have often proven equivocal [2]. Shifting towards mechanistically supported quantitative criteria thus appears necessary to overcome such ambiguities. Here, calcite dissolution experiments were conducted at room temperature and at various solution saturation states with respect to calcite (i.e., Ω = 0.00, 0.10, 0.30, 0.55, 0.65, 0.80) in alkaline conditions (pH = 7.9), either under sterile conditions or with a cyanobacterial biofilm of Chroococcidiopsis thermalis PCC 7203 cells covering the calcite surface. Nanoscale chemical and crystallographic characterizations failed to detect any distinctive biogenicity feature. Conversely, at far-from-equilibrium conditions (i.e., $\Omega \leq$ 0.30), high-elevation regions at the calcite surface were uniquely detected through statistical characterizations of the surface microtopography, making microbially-weathered surfaces quantitatively distinguishable from their abiotic counterparts. Kinetic Monte Carlo (kMC) simulations of the dissolution process suggested that these microtopographic imprints resulted from a local increase in fluid saturation state at the biofilm-mineral contact, leading to a localized reduction in dissolution rates. Current efforts are aimed at monitoring the formation of such biosignatures in real-time, through dissolution experiments performed using *in situ* vertical scanning interferometry. Preliminary results confirmed the ex-situ findings, suggesting that the calcite microtopography resulting from cyanobacteria-mediated dissolution may preserve a record of the interplay between biofilm coverage, metabolic activity, and calcite reactivity.

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