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The ultrastructure of carbonate minerals for discerning their biotic or abiotic origin

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Carbonates are indubitably the most common bio-mediated minerals present in the whole geological record. A variety of microbial micro-ecosystems (comprising microorganisms and organic products) can mediate their precipitation, in marine and terrestrial environments, even in very extreme conditions, forming deposits known as microbialites. Stromatolites, a common type of microbialites, provide some of the evidence for the existence of the earliest life on Earth.
Identification of the micro-nano scale components and mineral fabrics helps in understanding the role of organisms and the processes in microbialite formation. Although trapped grains, fossilised prokaryotes and micro-eukaryotes, are relatively easily interpreted in terms of origin and role, fine to coarse carbonate crystals (micrite to sparite), fundamental components of all microbialites, often present a challenge in terms of a biogenic or abiogenic origin. Moreover, while in many microbial communities the biochemical processes leading to carbonate precipitation have been examined in the field and reproduced in laboratory cultures, the mechanisms of crystal nucleation and growth, the final textures of the deposit, as well as the processes of fossilisation of the organic components, and then ultimately the diagenesis of neomorphic precipitates, have been less thoroughly investigated.
Here are compared the results of several studies of modern carbonate-producing biofilms and fossil microbialites, as well as carbonate bio-induced precipitates in laboratory cultures; all have demonstrated that a basic common mineral ultrastructure, composed of a granular texture due to the clustering of nanoparticles (of unclear nature), is recognisable in the biotically mediated minerals, even after diagenesis.
As this type of ultrastructure lacks in the abiotic mineral counterparts, forming in consequence of a ions-mediated crystallization, it is likely that the ultrastructure of carbonate minerals can be used to discriminate their origin in terms of a biotic versus abiotic origin.