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Distinguishing between biologically induced and biologically controlled mineralization in fossil organisms using electron backscatter diffraction (EBSD)

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Although carbonate-precipitating cyanobacteria are ubiquitous in aquatic ecosystems today, the criteria used to identify them in the geological record are subjective and rarely testable. Differences in the mode of biomineralization between cyanobacteria and metazoans, i.e. biologically induced calcification (BIM) vs. biologically controlled calcification (BCM) might be possible to discern through different crystallographic structures in which they result. We employed electron backscatter diffraction (EBSD) to investigate the structure of calcareous skeletons in two microproblematica widespread in Paleozoic marine ecosystems: *Rothpletzella* Wood 1945, considered to be a cyanobacterium, and *Allonema* Ulrich & Bassler 1904. We used a calcareous trilobite shell as a reference.
The shell of *Allonema* has a simple single-layered structure of acicular crystals perpendicular to the surface of the organism. The *c*-axes of these crystals are parallel to the elongation and thereby normal to the surface of the organism. The pole figures and misorientation axis distribution reveal a fiber texture around the *c*-axis with a small degree of variation (up to 30°), indicating a well-organized structure. A comparable pattern was found in the trilobite shell. This structure allows excluding biologically induced mineralization as the mechanism of shell formation in *Allonema*. In *Rothpletzella* the *c*-axes of the microcrystalline sheath show a broader clustering compared to *Allonema*, but still reveal crystals tending to be perpendicular to the surface of the organism. The misorientation axes of adjacent crystals show a random distribution. However, *Rothpletzella* also shares other morphological similarities with fossil and extant cyanobacteria. We propose that the strict limitation of rotations (misorientations) between adjacent crystals around a specific axis of the crystal system can be used as a criterion to distinguish shells formed through biologically controlled biomineralization.