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Bacterial EPS as a mediator of calcium carbonate morphology and polymorphism

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BIOLOGICALLY influenced mineralization either on the surfaces of, or in close proximity to bacterial cells may produce minerals that display distinct mineralogical or morphological features as a consequence of the microbial influence on the precipitation process. Characterizing such distinguishing features could potentially facilitate identification of early life in the geological record.

Many recent investigations have aimed to identify unique 'markers' indicative of biologically influenced mineralization, and to constrain the mechanisms controlling such precipitation. This study investigated the effects of bacterial extracellular polymers (EPS) on calcium carbonate morphology and polymorphism. Free-drift mineralization experiments were conducted using cells of the EPS-producing *Bacillus licheniformis* S-86 that either had the EPS layer intact (native cells) or had the EPS layer removed (EPS-free cells). In addition, experiments were undertaken in the presence of the extracted EPS-solution, without bacterial cells. These experiments were compared to an abiotic control. Crystal morphology was analysed by SEM and mineralogy was determined by XRD.

It was found that the control and EPS-free cell experiments contained vaterite and calcite when sampled after 12 h and 48 h, whereas the native cell and EPS-solution experiments contained only calcite, suggesting that the presence of EPS inhibits the formation of vaterite as a precursor to the stable polymorph, calcite. It is proposed that dissolved organic carbon (DOC) released from the EPS complexes Ca^{2+} ions in solution, reducing the calcium carbonate saturation and favouring calcite precipitation over vaterite. After 7 days, all experiments contained only calcite, indicating that the metastable polymorph vaterite is not stabilized by the presence of organic matter under these experimental conditions. However, distinct morphological differences between the calcite crystals precipitated in the four experiments were preserved after a period of 7 days, raising the possibility that crystal morphology may be an indicator of the biological conditions under which calcite has precipitated.

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