The evolution of biomineralization: Microbes, minerals, methods, products, processes - progress?

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The biogeochemistry of mineral precipitation and dissolution is one of the most studied geomicrobiological processes. Baas Becking investigated details of this process over eight decades ago, but many principles remain elusive today. In recent years, several new approaches in biomineralization research have shed some new light; novel techniques include a plethora of molecular biological, analytical chemical and physical as well as microscopic methods. Systems under investigation range in scale from nanometer and millisecond for mineral nucleation to kilometer and millennia to epochs (and longer) for system development and preservation in the rock record.

Here I review a few such approaches: some that are particularly unusual, for example, the use of geographic information systems (GIS) to understand geomicrobial processes on a biofilm scale; molecular observations using technologies developed for medical applications to estimate microbial contributions to diagenetic processes; or classic sedimentological techniques that build on potential mechanisms of mineral precipitation, often using multidisciplinary expertise. This review will focus on research carried out in organosedimentary systems called microbial mats. These sediment ecosystems are of particular interest as similarities in their meso-fabric in contemporary mats and those found in the rock record suggest a potential link between the earliest evidence of life and that present in certain contemporary, often “extreme” environments. In fact, some of these “extreme” environments may harbor geomicrobial ecosystems that represent the best analogs for Precambrian life known to date. Needless to say, it is critical to link multifaceted approaches to well-defined questions that address mineral precipitation and biomineralization in extant systems in an attempt to link the present to the past.