Geophysical Research Abstracts,
Vol. 11, EGU2009-4158, 2009
EGU General Assembly 2009

Evidence of microbial biomineralization processes in modern and ancient stromatolites

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Carbonate microbialites representing microbial mat and/or stromatolite development are remarkable fossils from the early Earth's environment. Even though their biogenicity can be questionable, since they often lack any proof of the original microorganisms in the form of fossil and rarely retain their primary bio-geochemical signature, recent studies of sub-fossil and fossil stromatolites demonstrate that microbialites can do preserve evidence of microbial biomineralization processes.
Modern lithifying microbial mats produce a range of carbonate precipitates resulting from the interplay of the biological activities of microorganisms and the environmental conditions. The environmental control on organic matter consumption and the saturation state of the solution are the crucial factors that drive precipitation. The mechanisms of crystal nucleation and growth, such as the final texture of the minerals and the fossilization of the organic components, are recognizable in low diagenized Olocenic stromatolites. The latter show diversified fabrics characterized by thin or crude lamination and/or thrombolitic clotting, but exhibit a pervasive peloidal micro-fabric consisting of dark micritic aggregates surrounded by limpid crystals of aragonite arranged in spherulitic aggregates. The co-existence of sub-micron flat and filamentous mucus-like remains of degraded EPS and fossilized bacteria, strictly associated with the carbonate phases, implies that the organic matter and the microbial metabolism played a fundamental role in the precipitation of the minerals. The initial products of calcification are nano-globules (60-200 nm) that subsequently are merged into larger spheres (200–500 nm), playing a primary role as centres of nucleation for succeeding crystal growth. Sub-micron crystals, resulting from the coalescence of carbonate nano-globules around degraded organic matter (EPS and/or bacterial bodies) nuclei, growth forming larger aggregate that constitute dark peloids. Precipitation of aragonitic spherulites around peloids than occurs filling inter-peloidal space. This process results in the formation of a structure that has an intimate mixture of peloidal micrite and microspar, well comparable to the microstructures of Triassic stromatolitic and thrombolitic microbialites, which also preserve fossilized bacteria and sub-polygonal networks reminiscent of EPS. These features confirm a biological origin for these ancient microbialites through similar microbial-mediated biomineralization processes occurring in the modern lithifying microbial mats.