GEOMICROBIOLOGICAL OBSERVATIONS AND A CONCEPTUAL MODEL FOR LITHIFICATION IN MODERN MARINE STROMATOLITES

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The surface of modern marine stromatolites, found in the subtidal and intertidal zone of the Exuma Cays, Bahamas, constitute of cyanobacterial mats. The presence of such a microbial community in these lithified structures suggest biogeochemical mediated stromatolite formation. Microscale investigations carried out in Highborne Cay, at the north end of the Exuma Cays , and included *in situ* and shipboard measurements. Biogeochemical investigations included geological observations such as thin sectioning, SEM, and measurements of the distribution of lithified and unlithified horizons with a micro-penetrometer. Microbial analysis included rate measurements with microelectrodes and radiolabeled substrates and population determination with epifluorescence microscopy and serial dilutions in specific microbial media. Also determined were microbial community composition, inorganic nutrients and sulfur species in the porewater, pH depth profiles, and organic nutrient utilization by various groups of microorganisms.

Accretion of carbonate sand, which is importan at for Exuma stromatolite formation, is mediated through trapping and binding by filamentous cyanobacteria. Active precipitation and dissolution mediated by various types of bacteria yields lithification of the accreted carbonate sand. In addition, endolithic microboring by cyanobacteria results in micritization. Combining the biogeochemical microscale observations described above led to a conceptual model in which spatial and temporal separation of other microbial processes also contribute to formation of lithified horizons: Oxygenic photosynthesis precipitates calcium carbonate while aerobic respiration by heterotrophic bacteria dissolves this. Furthermore, sulfate reducing bacteria and sulfide-oxidizing bacteria play an important role in formation of micritized layers. When oxygen concentrations are low, sulfate reduction rates are high. Under these conditions, the sulfide produced during sulfate reduction is only partially oxidized. Reduction of sulfate and oxidation of sulfide combined result in a high precipitation rate. When oxygen concentrations are sufficiently high again (and as a consequence, sulfate reduction rates low), complete oxidation of the sulfur intermediates lead to calcium carbonate dissolution. However, diffusion of microbial metabolites may facilitate a further decoupling of processes in space and time. The current challenge is to further decrease the spatial and temporal scales of biogeochemical observations, preferably in a non-destructive way.