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# Geomicrobiology of Holocene Freshwater Microbial Mud in the Florida Everglades

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The Florida Everglades provide a modern analog to study the comparative sedimentology of palustrine lime mud deposits. Initial calcite crystal formation occurs within surface microbial mats. Over time, these mat deposits accumulate and the organics are degraded to form dense carbonate muds. To assess how microbial communities influence pore water geochemistry and resulting geochemical and textural signatures of the carbonate, modern and Holocene freshwater mud deposits were studied along a low-energy shoreline. Our prior research has characterized the textural and geochemical characteristics of the sediments and pore waters. We expand on these studies by integrating a whole-genome metagenomic analysis from a subset (n=14) of previously studied samples, (6 from a core near Paurotis Pond, 5 from a core near the mangrove transition zone (MTZ), 2 from a Holocene freshwater mud deposit in a core at Whitewater Bay (∼1m depth), and a single sample from a Holocene deposit at the bottom of a core (∼3m depth) taken in the offshore marine environment at Murray Key). Shotgun genomic libraries were sequenced on the HiSeq 4000 (Illumina) platform. We used the MEGAN pipeline to perform NCBI taxonomy assignment and functional annotation for KEGG. Multivariate analyses based on taxonomy or functional genomics, showed clear differences between localities as well as a gradation from top to bottom of the Paurotis Pond and MTZ cores. The surface mats at Paurotis Pond and MTZ show a dominance of Cyanobacteria, the most common being Leptolyngbya and Scytonema. Surface cyanobacterial mats show elevated occurrences of genes associated with photosynthesis, $CO_2$ fixation, and nitrogen fixation. These communities induce the formation of texturally complex Low-Mg calcite crystals. Both the Paurotis Pond and MTZ cores show the highest alkalinity associated with the surface cyanobacterial mats (4-5 times overlying surface waters). A number of other phyla show either increasing or decreasing trends down core. Phyla that show decreases down core include the fermenting groups Bacteroidetes and Firmicutes as well as the Alphaproteobacteria group including the photosynthetic genera Rhodospirrillum. Bacterial Phyla that show an increasing trend down core include the Acidobacteria, Nitrospirae, and the Rokubacteria. Within the Deltaproteobacteria, the Desulfobacterales group also show a clear increasing trend down core. Genes associated with nitrification and nitrate reduction peak at intermediate depths in the Paurotis Pond and MTZ cores. Genes associated with sulfate reduction were greatest in the lower sections of the MTZ cores. Below the surface mat, alkalinity drops dramatically before gradually increasing to the base of the cores. The dramatic drop in alkalinity is likely a product of aerobic respiration and anaerobic fermentation of labile organics. Despite the presumed stability of the Low-Mg calcite, the resultant mud is extensively altered during early burial. The Domain Archaea appears to be more common at depth and seaward in the Whitewater Bay and Murray Key Cores. Functional genes associated with anaerobic reductive dehalogenation and methanogenesis were most prevalent in the samples taken from these cores. Low-Mg calcite crystals from these environments can be similar to the unaltered surface mats at Paurotis pond or the MTZ.