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Microbial communities from Lagoa Vermelha and Brejo do Espinho, Brazil: the role in carbonate mineralization in a hypersaline lagoon system

MS. FERNANDA JAMEL, PHD STUDENT[1], FERNANDO ROSSI[1], BEATRIZ AKITI[1], FLAVIA CALLEFO[2], BRUNA BOSSARD[1], MACIEL LUZ[3], FABIO RODRIGUES[1] AND DOUGLAS GALANTE[1]

[1]University of São Paulo
[2]University of Campinas
[3]Instituto de Pesquisas Tecnológicas

Microbial mats and stromatolites can be considered critical modern analogs for Precambrian environments, providing insights into the microbial communities that shaped early Earth through biomineralization. This study examines the microbial community structure and functional potential of mats in the Hypersaline Lagoon System of Araruama (HLSA), Brazil, with a specific focus on the Lagoa Vermelha and Brejo do Espinho ecosystems, where dolomite precipitation actively occurs. Using metagenomic analysis of five distinct sampling sites (BE, SL1, LN, LNEST, and LNSulf), we characterized the taxonomic diversity and metabolic pathways involved in carbonate precipitation. Geochemical analyses revealed salinities ranging from 40‰ to 60‰ and low Mg/Ca molar ratios, indicative of active mineral formation. Metagenomic results showed that Pseudomonadota was the dominant phylum in most sites, with significant contributions from Bacteroidota and Chloroflexota depending on the local environmental gradients. Key functional roles were identified for genera such as Thiohalocapsa, Dichotomicrobium, and Desulfosarcina, highlighting the importance of sulfur cycling and anoxygenic photosynthesis in creating alkaline microenvironments. Furthermore, the presence of genes related to extracellular polymeric substances (EPS) and carbonic anhydrases suggests a robust biological framework for mineral nucleation. Our findings demonstrate that the spatial complexity and metabolic versatility of these hypersaline communities are fundamental drivers of microbial-induced carbonate precipitation (MICP), reinforcing the role of modern lagoon systems as templates for understanding ancient microbialites.