

Understanding Modern Stromatolite Formation Mechanisms: Insights from microbialites in Kenting, Taiwan

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Stromatolites, representing some of Earth's earliest evidence of life, provide invaluable insights into ancient environments and microbial processes. Despite their prevalence in pre-Cambrian times, modern stromatolites are rare, making their study crucial for understanding microbial-mineral interactions and sedimentary processes. This study focuses on modern stromatolites discovered in the intertidal zone of Kenting, Taiwan, offering a unique opportunity to investigate contemporary microbialite formation and biomineralization mechanisms.

Using nucleic acid sequencing and environmental functional predictions, we analyzed microbial communities and the abundance of metabolic functional genes within microbial mats, which serve as precursor structures of stromatolites. Our findings underscore the dominance of filamentous cyanobacteria, particularly the third category (branchless, non-heterocystous Oscillatorials), and their crucial role in biomineralization. We observed mineralized microtubes, primarily composed of Mg-Calcite, radiating outward from multiple nucleation points on microbial surfaces, indicating a rapid biomineralization process initiated by amorphous minerals due to active photosynthetic activity. These mineralized microtubes contribute to the scaffolding structure in the layering of stromatolites.

Furthermore, our study elucidates the relationship between microbial species, metabolic activities, and the formation of mineralized microtubes. We found that areas where microtubes form coincide with the primary growth zones of cyanobacteria, exhibiting the highest abundance of metabolic functional genes within microbial mats.

In summary, our research in Kenting provides crucial insights into the formation mechanisms of modern stromatolites through biomineralization, highlighting the pivotal role of filamentous cyanobacteria in shaping microbialite structures and layering. These high-precision findings deepen our understanding of stromatolite formation processes.