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Bioflumology: Microbial Mat Growth in Flumes

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Abstract

The emergence of oxygenic photosynthesis resulted in a transformational change of Earth's geochemical cycles and the subsequent evolution of life. However, it remains vigorously debated when this metabolic ability had evolved in cyanobacteria. This is largely because studies of Archean microfossil morphology, molecular biomarkers, and isotopic characteristics are frequently ambiguous. However, the high degree of morphological similarities between modern photosynthetic and Archean fossil mats has been interpreted to indicate phototactic microbial behavior or oxygenic photosynthesis.

In order to better evaluate the relationship between mat morphology and metabolism, we here present a laboratory set-up for conducting month-long experiments in several sterilizable circular flumes designed to allow single-species cyanobacterial growth under adjustable fluid-flow conditions and protected from contamination.

1. Motivation

Cyanobacterial mats grown under axenic laboratory conditions develop reticulate textures and associated tufts or pinnacles (Fig. 1). It has been suggested that these specific morphologies might be a direct result from their phototrophic behavior [1]. However, these experiments were conducted using mats grown in low-energy, standing-water settings which are unlikely conditions for natural shallow-water shorelines, thus limiting their conclusiveness.

Other studies have conducted non-axenic flume experiments with mats retrieved from their natural environment in order investigate how their presence affects the movement of single grains and the development of sedimentary bedforms [2]. The aim of this study is to combine both experimental approaches and to grow an axenic cyanobacterial mat under fluid-flow conditions.

2. Hypothesis

We assume that two hydrodynamic aspects are of particular importance for the development of different mat morphologies: 1) the bed shear stress acting on the mats and 2) whether the entire microbial mat resides within the laminar sublayer or if parts of it breach into the transitional turbulent flow. These hydrodynamic aspects are investigated theoretically and experimentally.

3. Outlook

We expect that our cyanobacterial growth experiments will advance our understanding of how diffusion limitation and hydrodynamic shear stress affect the morphology of photosynthetic mats. This, in turn, will improve comparisons with fossil mats on Earth and assist in the search for biosignatures on Mars.

References: [1] Sim, M. S., Liang, B., Petroff, A. P. et al. Geosciences, 2, 235-259, 2012. [2] Hagadorn, J. W. & McDowell, C. Sedimentology, 59, 795-808, 2012.

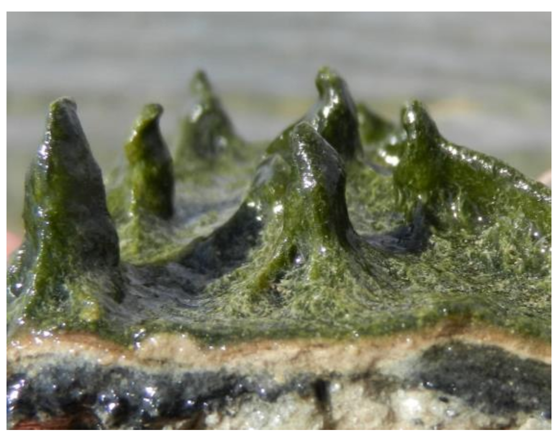

Figure 1: Tufted microbial mat developing within the intertidal zone in the Bahar Alouane, Tunisia. Width of the image is 3 cm