The significance of conical mats

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Conical stromatolites are some of the most distinctive fossil microbial communities in the geologic record. Cones have been hypothesized to form by the phototactic motion of the filamentous bacteria up slopes (1). Recent models suggest that they form in response to growth in stagnant fluids where diffusion limits exchange of nutrients and wastes with the environment (2) and that O_2 production and consumption may be critical in mediating cone development (3). Understanding the processes driving cone formation is critical to interpreting the metabolic evolution of life and the history of biogeochemical interaction with the environment.

Cultures of a filamentous cyanobacterium isolated from cones in Yellowstone National Park, Montana, U.S.A. (*Leptolyngbya sp*. Y-WT-2000 Cl 1) were grown on various surfaces. High resolution time lapse videos were collected to document movement of groups of organisms. After 10 days of incubation, vertical tufts of alligned bacteria grew and merged to form small cones with 1-2-mm-long horizontally radiating "star arms". At this stage, cones aggregated from dispersed bacteria during the morning and disaggregated in the evening. Cones moved randomly across surfaces at rates of up to 10 μm s^{-1} during the middle of the day, merging upon contact between star arms to form larger cones. Cones increased in number and size over several days, eventually covering the surface with a network of ~10-mm-high cones.

Cone formation was directed by cell-cell contact, not by gradients in any field. The effect of cone aggregation was to concentrate clumps of cells on underlying points of positive topographic curvature, likely maximizing local biofilm surface area. Cultures grown on large artificial projections grew faster when closer to the water/air interface, suggesting that diffusion-limited transport of CO_2 or O_2 could shape the morphogenesis of larger cones. These results partially support models of cone formation that implicate diffusive exchange with the environment as a determinant of cone growth, but suggest that the mechanisms by which cones form are likely related to contact-mediated social movement rather than specific metabolisms or phototaxis.

[1] Walter *et al* (1976) in Walter, ed. *Stromatolites: Developments in Sedimentology* **20**, New York, Elsevier, 273-310. [2] Petroff *et al* (2010) *PNAS* **107**, 9956-9961. [3] Sim *et al* (2012) *Geosci*. **2,** 235-259.