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Vertical microbial community variability of carbonate-based cones may provide insight into ancient conical stromatolite formation

James Bradley (1), Leslie Daille (2), Christopher Trivedi (3), Caitlin Bojanowski (4), Heather Nunn (5), Blake Stamps (5), Hope Johnson (6), Bradley Stevenson (5), Will Berelson (7), Frank Corsetti (7), and John Spear (3)

(1) School of Geographical Sciences, University of Bristol, Bristol, UK, (2) Pontifical Catholic University of Chile, Santiago, Chile, (3) Colorado School of Mines, Golden, USA, (4) University of Dayton, Dayton, USA, (5) University of Oklahoma, Oklahoma, USA, (6) Biological Science, California State University, Fullerton, Fullerton, USA, (7) University of Southern California, Los Angeles, USA

Stromatolite morphogenesis is poorly understood, and the process by which microbial mats become mineralized is a primary question in microbialite formation. Ancient conical stromatolites are primarily carbonate-based whereas the few modern analogues in hot springs are either non-mineralized or mineralized by silica. A team from the 2015 International GeoBiology Course investigated carbonate-rich microbial cones from near Little Hot Creek (LHC), Long Valley Caldera, California, to investigate how conical stromatolites might form in a hot spring carbonate system.

The cones rise up from a layered microbial mat on the east side of a 45° C pool with very low flow that is super-saturated with respect to $CaCO_3$. Cone structures are 8-30 mm in height, are rigid and do not deform when removed from the pool. Morphological characterization through environmental scanning electronic microscopy revealed that the cone structure is maintained by a matrix of intertwining microbial filaments around carbonate grains. This matrix gives rise to cone-filaments that are arranged vertically or horizontally, and provides further stability to the cone.

Preliminary 16S rRNA gene analysis indicated variability of community composition between different vertical levels of the cone. The cone tip had comparatively greater abundance of filamentous cyanobacteria including Leptolingbya, Phormidium and Isosphaera and fewer heterotrophs (e.g. Chloroflexi) compared to the cone bottom. This supports the hypothesis that cone formation may depend on the differential abundance of the microbial community and their potential functional roles.

Metagenomic analyses of the cones revealed potential genes related to chemotaxis and motility. Specifically, a genomic bin identified as a member of the genus Isosphaera contained an hmp chemotaxis operon implicated in gliding motility in the cyanobacterium Nostoc punctiforme. Isosphaera is a Planctomycete shown to have phototactic capabilities, and may play a role in conjunction with cyanobacteria in the vertical formation of the cones. This analysis of actively growing cones indicates a complex interplay of geochemistry and microbiology that form structures which can serve as models for processes that occurred in the past and are preserved in the rock record.