Formation of stromatolitic structures by *in vitro* cyanobacteria culturing

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Stromatolites are layered microbialites formed mainly by cyanobacteria. The morphology of cyanobacterial biomat likely controls 3-D domal structure of stromatolites; however, details of stromatolite-forming mechanism are still unknown. In this study, we aimed to form the stromatolitic domal structures, by *in vitro* culturing 10 species of 6 cyanobacteria genera (e.g. *Phormidium*) that live in Recent stromatolites. Four stages are likely inevitable in stromatolite formation; 1) start from a plane biomat, 2) development of an upward convex structure, 3) lamina-formation within a domal structure, and 4) calcification (lithification). We conducted experiments for the first three stages, and skipped the last one because the control of subtle chemical conditions for calcification is highly difficult at present.

After we succeeded in constant preparation of plane biomats for every strain, we incubated 10 axenic strains of cyanobacteria individually, and observed morphology and growth patterns of convex structures formed on plane biomats. Five strains of the 10 examined cyanobacteria built upward convex structures on biomats. It is noteworthy that two cyanobacteria (*Nostoc* sp. A (M270) and *N*. sp. B (M272)) formed stromatolitic domal structures that were mainly filled with polysaccharides. The domal structures remain for more than half a year, suggesting their better chance for preservation as fossils.

The intermittent sediment cover experiment over cyanobacterial mats was performed once a week, using fine grained glass-beads (about 63 micrometer in diameter). For each strain, 3 runs were conducted with different thickness of covered layers; 1 mm, 0.5 mm, and 0.04 mm.

M270 formed domal structures by 0.5 mm-thick and 0.04 mm-thick covers, but not at 1 mm-thick. Domal lamina of cover sediment formed within domal structures by 0.04 mm-thick cover. Each laminae corresponds to one sediment cover. Course grains quickly sank to the bottom of the biomat within a few minutes without forming lamina in domal structures at 0.5 mm cover. M272 showed the same results; formed domes with lamina only at 0.04 mm cover. These results suggest that the thickness of covered clastic layer is critical in forming both domal structures and internal lamina. Each cyanobacterial species may have its own threshold thickness for cover sediments.

The observed laminated domes of M270 and M272 resemble some taxa of the Precambrian domal stromatolites, e.g. *Omachtenia simplex* Zhu and *Yangzhuangia columnaris* Zhu by Cao and Yuan, 2006. These represent the first and the best example of domal structure with internal lamina in the laboratory ever reported.