Convex structures of cyanobacterial mat and their shape change in sediment-cover experiment with respect to stromatolitic layering

Atsushi Yamamoto[1]; Yukio Isozaki[2]

[1] Earth and Planetary Sci., Tokyo Univ.; [2] Earth Sci. & Astron., Univ. Tokyo Komaba

The morphological diversity of stromatolites is regarded to have evolved along with contemporary bacterial community through geologic time. However, the species selectivity of cyanobacterial mats and their controlling mechanism to morphology are still unknown. Upward convex structures formed on calcified mats are likely preserved as stromatolitic structures. Around their trichomes, cyanobacteria secrete extracellular polymeric substances (EPSs) that induce calcification of mats, as carboxyl groups of EPSs bind Ca^{2+}. In this study, we incubated 10 axenic strains of cyanobacteria individually for more than a half year under light at 31 ^{0}C, and observed morphology and growth patterns of convex structures formed on biomats. We used axenic strains of IAM Culture Collection, Univ. Tokyo, and A-1 Medium for cultivation.

Seven strains of the 10 examined cyanobacteria built convex structures on their mats and the rest 3 formed plain mats. Two distinct types of convex structures were recognized, i.e., Cyanobacterial Trichomes(CT)-type (e.g., IAM M99) and Polysaccharide(PS)-type (e.g., IAM M270). The CT-types are conical, 5 mm or less in height, and constructed by CT. The PS-types are dome-like, over 5 mm in height, and constructed by EPSs. Both types have a mat-building cycle that lasted for about 3-4 months. One cycle has 5 stages: i.e., 1) absent, 2) starting, 3) vertically growing, 4) horizontally expanding, and 5) fading stages. The convex structures existed from the 2) to 5). The convex structures of the PS mats are larger than those of the CT. The 3) and 4) of each mat-type are characterized by clear convex structures. The 3) and 4) of the CT mats lasted for about 3-4 days, but those of the PS for about 2-3 months. This suggests that the CT structures can be preserved only under special environments, such as modern hot springs where mats harden rapidly by hydrothermal mineralization. In contrast, the PS structures may be preserved under normal environments where most fossil and modern stromatolites were formed.

Recent stromatolites grow upward, resisting sedimentary burial. We observed growth patterns of the biomats under a sediment-filling condition, by supplying glass beads to form a 1-2 mm thick layer intermittently, every week. The weekly interval of sediment supply corresponds to a mean between the minimum time of biomat formation and the minimum time to reach the 5). This experiment revealed that the CT mats could leave one bacterial layer between two beads-layers only in the case of the transitional stage between the 4) and 5), and that the PS mats left an EPS-layer in a beads-layer every week during the 2)-4). During the non-growing 1) and 5), both the CT and PS mats could not leave any organic layer but a massive beads-layer. After one mat-building cycle was completed, the CT mat left a pair of a thick sediment-layer and a thin bacteria-layer, whereas the PS mat a pair of one thick beads layer and one composite layer of interbedded sediment/EPS.

The above observation suggests that the CT mat keeps accumulating pairs of a thin bacterial layer and a sediment layer as long as sediments are supplied periodically. Even in the same environment, the PS mat accumulates pairs of a composite organic layer and a sediment layer. Both types may result in the same thickness because each mat-building cycle has a constant duration dependent on cyanobacterial species. The two types of biomat layering recognized in this study may also be found in natural environments. The preservation of these layering structures likely depends on the diagenetic decomposition of organic matter. Fossil and recent stromatolites need to be checked if they have similar structures examined in the current study.