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Processes of stromatolite formation examined from the modern analogs

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Stromatolites, macroscopically laminated domal, columner and lentic shaped sediments, are an abundant sedimentary facies in Precambrian carbonates. Despite of 100-yr-long study history of taxonomy, paleontology, and sedimentology for understanding early biosphere and ocean chemistry, the detailed formation processes have not been well defined because the initial structures and chemical features were obscured due to recrystallization, deformation, and scarcity of microfossils. After the discovery of the modern stromatolite at restricted marine settings such as Bahamas and Western Australia (e.g. Logan, 1961), the detailed processes for the stromatolite formation have revealed, for example, growth by trapping and binding of detrital particles in the surface cyanobacterial mat, and lamina formation by cyanobacterial phototactic behavior and intermittent sediment supply. These processes were often adopted for interpreting the genesis of ancient stromatolites, however, its applicability is doubtful because the fabrics consisting of in situ precipitated carbonate minerals is different from the modern ones. Therefore, it is necessary to seek and investigate other modern analogs having similar fabrics to ancient stromatolites.

Travertines, carbonate precipitates from hot spring, have common fabrics to the ancient stromatolites in terms of sub-mm order lamination and scarcity of detrital particles. Travertines are inorganically precipitated by mechanical degassing of carbon dioxide from the water enriched with DIC and calcium ion. Previous studies mainly focusing on calcite travertines have indicated that cyanobacterial daily biofilm formation overcoming the inorganic mineral precipitation formed daily lamination (Takashima and Kano, 2008). However, aragonite is another component of travertine and was the primary mineral of some ancient stromatolites (Grotzinger, 1989). Here, I study aragonite travertines to understand the geomicrobiological processes forming laminated textures.

Aragonite travertines consist of radially expanded needle crystals, which is different from calcite fabrics called as dendrite consisting of tree-like aggregation of rhombic crystals. Sequences of sampling through day and night showed the lamination in the aragonite travertines was also formed daily cycle. There are two types of processes forming lamina formation in aragonite travertines; one is cyanobacterial direct role for daily lamination by their daily migration, another is cyanobacterial indirect role by daily production of organic materials (Okumura et al., 2011). It was also observed rapid decomposition of microbes in the travertine, which prevent preservation of microfossils in the sediment. The textural features of the aragonite travertines such as radially expanded needle crystals and scarcity of microfossils are common in some Precambrian stromatolites.

Despite of differences in water chemistry, hydrological setting, and mineralogy, geomicrobiological processes in the daily-laminated travertines show one detailed microbial behavior for interpreting the Precambrian stromatolites. If the relationship between stromatolite texture and microbial processes is clearly confirmed by geomicrobiological studies for modern analogs, it leads new possible interpretation for the stromatolite microbiology and the early biosphere.

References

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