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Microbial processes forming lamination in hot spring stromatolites by sulfur oxidizing bacteria and cyanobacteria.

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Travertines are carbonate precipitates from hot-spring water containing a sufficient amount of calcium and carbon dioxide. Most of travertines show sub-mm order laminations that were resemble to ancient stromatolites. Recently, daily microbial processes were identified in some travertines precipitated from some sulfide-poor and moderate temperature (<55 degree C) springs. In the process, daily growth of biofilms consisting cyanobacteria or heterotrophic bacteria, which inhibited inorganic mineral precipitation (1,2). While, lamination is less common in the travertines at higher temperature (>60 degree C) and sulfide-rich springs (3) likely because such daily microbe-mineral interaction might not be occurred. In order to understand the geomicrobiological system in high temperature and sulfide-rich spring, this study investigates a travertine in Sipoholon, Northern Sumatra, Indonesia.

Sipoholon hot spring forms the hugest travertine mound among the hot springs in Tarutung area located about 30 km south from the Lake Toba. The travertine mound spread in total area of 50,000 km^2. The actively precipitated region was separated 3 areas; A is natural mound without artificial effect, B is the mounds in a quarry, C is exposes the rim pools behind spa facilitates. In all area, sulfur-rich yellow sediments were formed near the vents, while white laminated sediment was formed from midstream to downstream. The surface color of the laminated travertine was changed with water temperature; pale pink around 55 degree C and green below 50 degree C. Lamination in the green travertine consisted of light colored crystalline layer and dark colored biofilm-rich porous layer in the interval of 0.5-1.0 mm. While, some lamination in the pink travertine was not clear.

12 sequences of water and travertine samples were collected at a green travertine and a pink travertine in Area C every 4 hours during 48 hours. Samples of both types of the travertine showed that the dark layer was formed during daytime and light colored layer was formed during nighttime without variation in pH, water temperature, Ca ion concentration, alkalinity, and flow. Only dissolved oxygen concentration showed the daily variation in the water chemistry, which was higher during the daytime and lower during the nighttime. Phylogenetic analysis on 16S rRNA gene showed that the pink and green travertines have a microbial composition dominated by obligatory chemolithoautotophic sulfur-oxidizing bacteria. Phototrophs, cyanobacteria and chloroflexus were more diverse in the green travertine than in the pink one. Epifluorescence microscopy showed that phototrophs were concentrated in the diurnal dark layer in the green travertine, while sparsely distributed near the surface in the pink travertine.

These results suggest that formation of phototroph biofilm in daily cycle was responsible for lamina formation in the green travertine same as previous study. On the other hand, formation of sulfur-oxidizer biofilm stimulated daytime increment of oxygen concentration was likely responsible for lamina formation in the pink travertine. The obscure lamination in the pink travertine possibly due to growth of chemolithoautotophs stimulated by extrinsic factor that is daily supplement of oxygen, in contrast to intrinsic daily growth of phototrophs. This novel microbial process could be occurred in ancient stromatolites formed under the anoxic sulfide-rich ancient ocean.

[Ref]
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