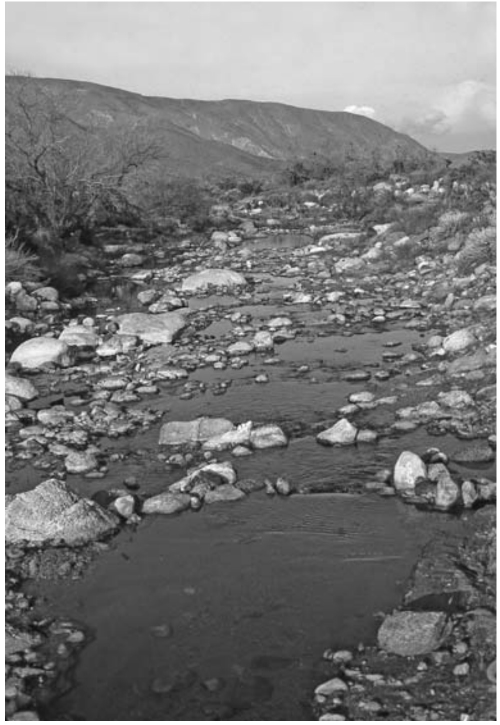
Stromatolites: What They Are and What They Mean to Us

Text and Photographs by Wayne P. Armstrong

One billion-year-old stromatolites embedded in limestone along Going-To-The Sun Road in Glacier National Park, Montana. The concentric rings represent calcareous layers where ancient colonies of cyanobacteria once thrived in shallow seas.

Stromatolites are layered (laminate), calcareous structures formed by colonies of cyanobacteria (formerly called blue-green algae). Along road cuts in Glacier National Park they resemble concentric circles embedded in limestone rocks. During countless centuries of time, calcareous sediments are trapped in layers of filamentous colonies of cyanobacteria. Like a coral reef, new colonies grow on top of the older ones as the stromatolite increases in height and diameter. Stromatolites were only known as ancient fossils until B.W. Logan (1961) first reported living stromatolites in warm, intertidal waters of Shark Bay in Western Australia. Called "cryptozoon stromatolites," they resemble reef-like domes composed of concentric layers where the cyanobacteria colonies once lived. This ancient calcification process is still going on to this day in several remote canyons of Anza-Borrego Desert State Park.

The abundance of stromatolites in the fossil record is evidence that photosynthetic cyanobacteria were among the first life forms on earth, dating back more than three billion years. They undoubtedly played an enormous role in elevating the level of free oxygen in the earth's atmosphere. As one gazes at the spectacular limestone formations in Glacier National Park and the Canadian Rockies, you are awe-struck with the enormous role these ancient cyanobacteria played as they removed carbon dioxide from primeval seas and precipitated it as massive calcium carbonate rocks. Releasing oxygen gas as a metabolic by-product, they must have been a major factor in producing the oxygen-rich atmosphere that allowed the development of other aerobic life forms on earth.In 1990, Dr. Paul Buchheim of the Department of Earth and Biological Sciences at Loma Linda University reported living stromatolites in Carrizo Gorge and San Felipe Creek in Sentenac Canyon, both within Anza-Borrego Desert State Park. Previous to this discovery, modern-day stromatolites were unknown north of Mexico. These shallow, ephemeral (intermittent) streams have boulders and cobbles coated with knobby, calcareous layers and living colonies of mucilaginous, filamentous cyanobacteria. Several species of cyanobacteria grow on the surface of submersed rocks, including tapered filaments of the stromatolite-forming genus Rivularia.

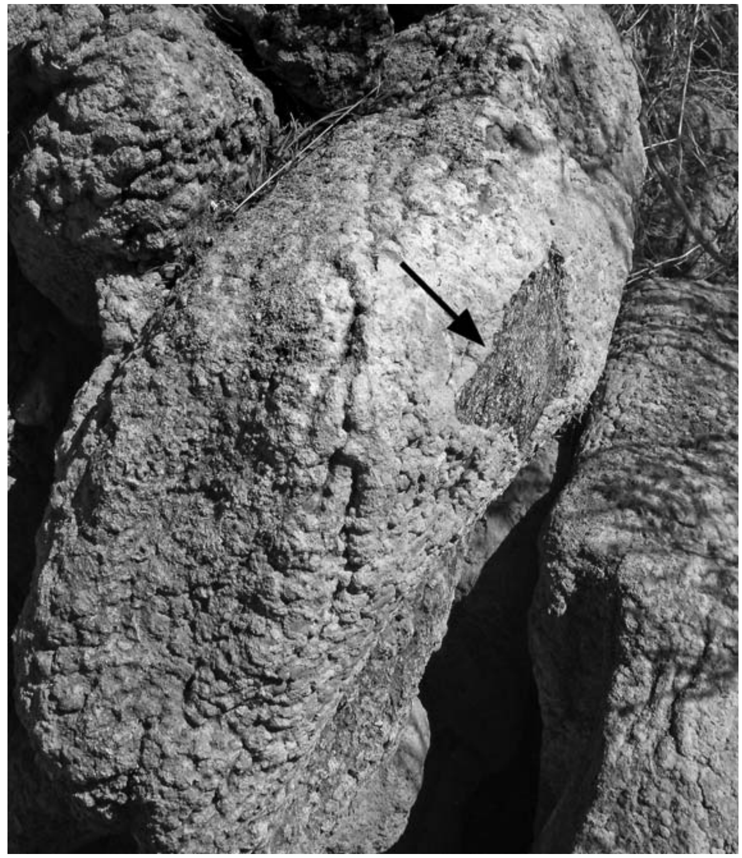


An ephemeral stream in Grapevine Canyon of Anza-Borrego Desert State Park. The submersed boulders and cobbles are encrusted with living colonies of stromatolite-forming cyanobacteria.

Magnified view of filamentous cyanobacteria resembling Rivularia living on submersed boulders in an ephemeral stream. Under ideal conditions, colonies of cyanobacteria similar to these are responsible for the deposition of calcareous layers known as stromatolites. Magnification 400x.

Filaments of Rivularia are covered with a slimy mucilaginous sheath that is fairly easy to see under high magnification (400x) with a compound microscope. Calcareous sediments (limestone) and detrital stream particles are trapped in layers of filamentous colonies of the cyanobacteria. Over centuries of time, stromatolites up to an inch thick accumulate on granite rocks and boulders. The cyanobacteria utilize water, carbon dioxide and sunlight during photosynthesis. Byproducts of this process are oxygen and calcium carbonate (lime). Debris from the water is trapped in the slimy mucous coating (sheaths) of the filamentous cyanobacterial mats and is gradually cemented together by the calcium carbonate. Presumably, intervals of creek desiccation facilitate in this cementation process, resulting in

The boulders and cobbles in this image were all submersed during the wet seasons of previous years. They are coated with a knobby (bumby) calcareous layer composed of microscopic laminae produced by colonies of cyanobacteria.



A stromatolite-covered boulder in Grapevine Canyon. The arrow points to a portion of the stromatolite layer that has broken away, exposing the granite core of the rock. In previous years this boulder was submersed in calcium-rich, alkaline water and supported dense colonies of cyanobacteria of the genus Rivularia.

layers composed of calcite and detrital stream particles. The biochemical process of lamina formation can be observed in modern microbial mats cultured in the laboratory. Occasional flooding down boulder strewn canyons during wet years undoubtedly scours away developing stromatolites and controls their thickness. Some of the best developed stromatolites in Carrizo Creek were destroyed by spring floods of 1993. According to Dr. Buchheim (personal communication, 2008), stromatolites have reestablished in Carrizo Creek, but droughts of the past several years have hindered their development.

Stromatolite growth in Anza-Borrego Desert is most abundant in ephermeral sections of alkaline streams, including Carrizo and San Felipe Creeks, where maximum evaporation takes place and where solutes are the highest. Most of my images of stromatolites were taken in an ephemeral stream of Grapevine Canyon that drains into Sentenac Canyon. The best formation of stromatolites occurs in areas where water flowed for only a few months in the spring of each year. The cyanobacterial mats apparently go into a dormant state when the creek becomes desiccated. According to Buchheim (1995), the major factor controlling stromatolite growth in these streams is high solute concentration as well as calcite supersaturation. This explains why stromatolites grow in some creeks of Anza-Borrego but not in others.

There are other calcareous deposits in alkaline desert riverbeds. Tufa deposits are common in desert alkaline streams, including Sentenac Canyon. Tufa is a white, porous calcium carbonate deposit that forms by chemical deposition in water supersaturated with calcium. It coats solid objects along creeks and the shores of lake beds. It is easily distinguished from stromatolites which have a layered (laminate) structure.

Desert stromatolites are especially interesting because they enable scientists to study colonies of these "living fossils" in their natural habitat. Stromatolites are important from an evolutionary standpoint because they are frequently the subject of scientific discussions about ancient climates and the origin of life on earth. They can be found in limestone areas throughout the world that were once covered by ancient seas. But to see this calcareous phenomenon actually forming in alkaline streams of Anza-Borrego Desert is truly remarkable.

For Further Reading

Buchheim, H.P. 1995. "Stromatolites: Living Fossils in Anza-Borrego Desert State Park." Pages 119-124 in: *Paleontology and Geology of the Western Salton Trough Detachment, Anza-Borrego Desert State Park, California*. Volume 1. P. Remeika and A. Sturz, Editors. San Diego Association of Geologists, San Diego, California.

Logan, B.H. 1961. "Cryptozoon and Associate Stromatolites From the Recent, Shark Bay, Western Australia." Journal of Geology 69: 517-533.