Karsting light on STROMATOLITES and THROMBOLITES

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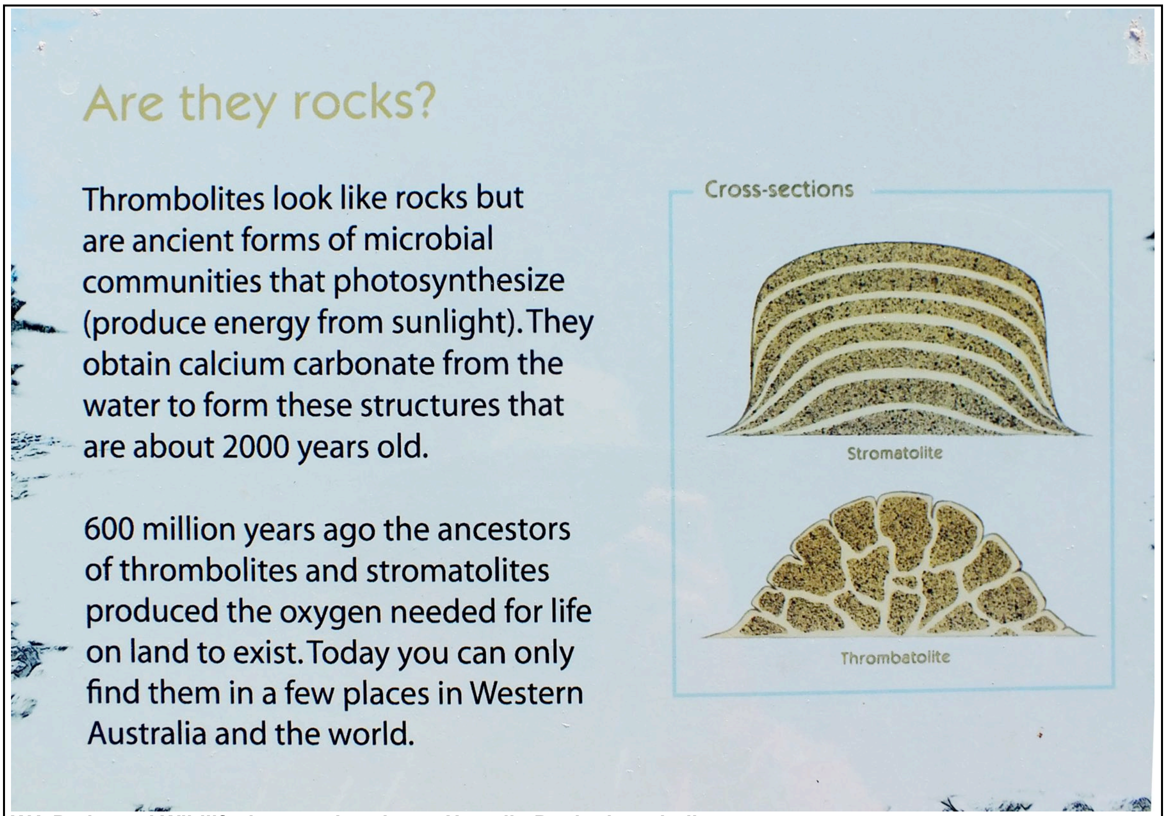
There are many locations around the world where large areas of limestone deposits, now karst areas, have been laid down primarily by microscopic photosynthetic organisms (cyanobacteria), which created stromatolitic and thrombolytic structures of calcium carbonate.

Cyanobacteria are prokaryotic cells (the simplest form of modern carbon-based life), which lack a DNA-packaging nucleus. These prokaryotic bacteria belong to the domain of life called Eubacteria. They appeared on earth about 3.5 billion years ago and were the only life form till about 1.5 billion years ago.

The prolific spread of cyanobacteria across the globe about 2.5 billion years ago, resulted in a gradual change in the earth's atmosphere from a carbon dioxide-rich to the present-day oxygen-rich. This paved the way for the next evolutionary step, the appearance of life based on the eukaryotic cell – a cell with a nucleus.

Therefore classifying the early life forms, which created stromatolites and thrombolites as colonies of photosynthesizing cyanobacteria is an oversimplification given the majority of scientific evidence suggests that all three domains of life (the Archaeans, Eubacteria, and Eukaryotes) appeared in the Archaean Era. The microbial mat colonies probably contained representatives from all three domains.

During Precambrian times, these photosynthetic bacteria flourished in shallow calcium-rich waters, taking in carbon dioxide and releasing oxygen. As a result of photosynthesis, they reduced the carbon dioxide content of the surrounding water, particularly within the sticky mucilage layers covering their surface. This small reduction in solution acidity causes precipitation of calcium carbonate within and around the mucilage which helped to cement together other sediment particles trapped within the sticky layers. The cyanobacteria produced the mucilage film as protection from the sun's ultraviolet



WA Parks and Wildlife, interpretive sign at Hamelin Pool - thrombolites.

radiation. The bacterial colonies grew layer upon layer of calcium carbonate along with any trapped sediment, while constantly reoccupying the uppermost layer to create large calcareous structures.

The prolific growth of photosynthesising cyanobacteria, often loosely referred to as marine algae, has created large areas of rocky structures which can now be seen in various locations around the world as laminated calcareous fossils. They are among the earliest fossil records on earth and their structures can even be seen on images taken from orbiting satellites. Such examples, up to 15 metre diameter, can be found in the Gregory National Park, Northern Territory, Australia.

WA Parks and Wildlife, interpretive sign about Stromatolites at Hamelin Pool.

Since being laid down in shallow lagoons, these laminated calcareous fossil beds have been overlaid with sediments, undergone upheaval due to tectonic plate movement and endured environmental weathering, so that today their remains can be observed in large areas of limestone karst containing significant cave systems.

Stromatolites still growing today at Hamelin Bay, in water twice as saline as usual seawater. Photo Garry K. Smith

The term **"Stromatolite"**, is derived from the Greek στρώμα, *strōma*, mattress, bed, stratum, and λίθος, *lithos*, stone, rock, which literally means 'layered rock' and are the actual solid structures created by the single-celled microbes called cyanobacteria.

Stromatolites are a major constituent of the fossil record of the first life forms on earth. The earliest stromatolites fossils date to 3.5 billion years ago. They peaked about 1.25 billion years ago and subsequently declined in abundance and diversity, so that by the start of the Cambrian they had fallen to 20% of their peak. The most widely supported explanation is that stromatolite builders fell victim to grazing creatures - the Cambrian substrate revolution). This theory implies that sufficiently complex organisms were common more than a billion years ago.

Thrombolites at Lake Clifton (WA). Photo by Garry K. Smith

Research by Linda Moore (University of WA) on the Lake Clifton **thrombolites** determined that they probably evolved from stromatolites; however thrombolites grew in intimate association with a variety of metazoan life for which they provided shelter within their clot-like structure. Thrombolites gained their name from the clot-like calcite structure which resembles thrombosis. The stromatolites' and thrombolites' downfall is that corals can grow much faster and could outcompete for precious sunlight in favorable saltwater environments.

Once widespread, there are now just a handful of isolated areas in the world where stromatolites and thrombolites are still growing today and several of these areas occur in Western Australia (WA). They include the stromatolites at Hamelin Pool in the Shark Bay World Heritage Area, stromatolites and thrombolites at Lake Thetis near Cervantes, and the thrombolites at Lake Clifton, south of Mandurah (see attached photos). They survive in harsh environmental conditions (e.g. high salinity water), which supports few marine animals to graze on them. The colonies of cyanobacteria which build these stromatolites today are similar to the earliest organisms to appear on earth and produced oxygen for subsequent life forms.

Western Australia is internationally significant for its variety of stromatolite sites, both fossilized and living. Research indicates that the present Hamlin Pool and Lake Thetis stromatolites have been growing for about 3,500 years. It can take a stromatolite a 100 years to grow just 5 cm, hence a metre-high stromatolite may be easily 2,000 years old. In a way it could be said that the thousands of very ordinary-looking rocks sitting in the shallow waters at these locations are alive. This statement is excellent for capturing the tourists' imagination, but it is somewhat an over exaggerated, given that it's really only the thin film of bacteria on the surface of the rock which is alive. It is true that the calcium carbonate structure underneath the biofilm was and continues to be accreted by a form of life which is the closest thing we can see to the first life on earth. In recent times, living stromatolites have also been discovered in a few other locations around the world, such as the Bahamas, the Indian Ocean and Yellowstone National Park. Their survival is constantly under threat wherever they exist today by the encroachment of human activity and our affect on the environment.

Walkway over the thrombolites at Lake Clifton (WA). Photo by Garry K. Smith

Walkway over the thrombolites at Lake Clifton, WA. Photo by Garry K. Smith

Sub-aerial *stromatolites* (accretions of calcareous algae in the shape of domes and craybacks) and the influence of the photosynthetic cyanobacteria will be the subject of another article in the future.

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Sonia Taylor-Smith next to damaged stromatolites at Lake Thetis (WA). These are reported to be up to 3,500 years old and still growing. Photo by Garry K. Smith

View from the boardwalk over the stromatolites in Hamelin Pool WA. Photo by Garry K. Smith

Garry examines stromatolites at Lake Thetis (WA). Photo by Sonia Taylor-Smith

Stromatolite domes up to 15metre diameter in a karst area of northern Australia. Photo by Garry K. Smith

A 15 metre diameter stromatolite dome in a karst area of northern Australia. Photo by Garry K. Smith

A cross section of a Stromatolite fossil in northern Australia. Photo Garry K. Smith.