LIFE IN STONE: The Long and Extraordinary History of Life in Our Office

Christa Sadler

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PRECAMBRIAN (4.6 billion to 544 million years ago)

- Life on Earth begins about 3.5 billion years ago: single-celled bacteria that often form stromatolites (later, when true algae evolves, it also form stromatolites). The earliest life in Grand Canyon is about 1.2 billion years old, in the Bass Formation of the GC Supergroup. Several of the Supergroup layers have stromatolites in them, most made of true algae. There are several species known in Grand Canyon, ranging in size from a few inches high to several tens of feet long. Multicellular life appeared about 700 million years ago, and may have been present in some of the later Chuar Group sediments, but the evidence is sketchy at best.

PALEOZOIC

Cambrian (544 to 490 million years ago) Tapeats, Bright Angel, Muav)

- The "Cambrian Explosion" in the early part of the Cambrian saw the beginnings of all the major groups of animals alive today. This diversification of life may have taken as little as five million years, which is, trust me, a really short time, geologically speaking.
- The Cambrian seas were dominated by animals that were filter feeders, that is, little bulldozers that dug food out of the sediment. We see evidence of this in the Tapeats Sandstone and Bright Angel Shale, where worm burrows and trilobite tracks are really common. There are some 40 species of trilobites in Grand Canyon, but none of them are all that well preserved. At the time of the Tapeats/BA/Muav, there was no life on land, although there are some things found in the Bright Angel that some researchers interpret as spores from land plants. If so, these are the earliest land plants known in the world. But as far as we know all life was in the ocean at this point.

Devonian (417 million to 359 million years ago) Temple Butte

- By the Devonian, fish had proliferated in the world's oceans and life on land was blossoming. Plants and arthropods had moved to land during the preceding hundred million years; rocks of this age are missing in the GC region. The Temple Butte Fm. represents a brackish estuary-to near shore- to offshore environment as you go further west. Near Flagstaff, numerous species of primitive armored fish have been found in this formation; in GC, the Temple Butte doesn't have many fossils but they are mostly invertebrates like brachiopods, corals and crinoid pieces.

Mississippian (359 million to 318 million years ago) Redwall Limestone

- During the Mississippian, the GC region was covered with a shallow, warm, limestone ocean, that basically stretched all the way across the continent, from mountains in Nevada to the rising Appalachians in the east. This ocean was dominated by filter feeders (critters that sucked food out of the water column), which indicates clear water with lots of nutrients in it and good circulation. Solitary horn corals, colonial corals, bryozoans, brachiopods, crinoids, sponges, fish, sharks, trilobites and nautiloids are especially common. The nautiloids of Nautiloid Canyon are probably a genus called *Rayonnoceras*. Other members of this genus found elsewhere in the US grew to six or seven feet in length.

Pennsylvanian/Permian (318 million to 285 million years ago) Supai Group , Hermit Shale

- At the end of the Mississippian, continental collisions to the east caused mountains to form in the Four Corners region and where the current Rockies are today. Sediments washed down off these ranges, covering the GC region with a thick blanket of sands, shales, and muds known as the Supai Group and the Hermit Formation. These layers represent river and floodplain, delta, coastal plain and coastal dune environments. Numerous tracks of reptiles and impressions of ferns, horsetail rushes and tree bark tell us that there was some vegetation in these environments, but it probably wasn't super lush.

Late Permian (285 to 251 million years ago) Coconino Sandstone, Toroweap and,Kaibab Fms.

- Less and less sediment was washing off the eroded mountains to the east and all the continents had almost joined together into the supercontinent Pangea. Climate became more arid and sand began to blow off the floodplains to the northeast towards the coast in central and western Arizona, creating the dune field of the Coconino. Reptiles, millipedes, beetles, spiders and scorpions crisscrossed the dunes, leaving their tracks. Finally, the sea invaded the land one last time, leaving the shallow waters of the Toroweap and Kaibab Formations. These waters sheltered clams, snails, brachiopods, sponges, bryozoans, trilobites, horn corals and crinoids, again indicating warm and shallow, clear and calm conditions.

MESOZOIC AND BEYOND (251 million to the present)

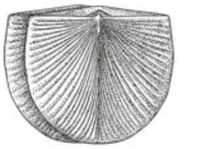
- Well, Pangea broke apart; there was a huge extinction at the end of the Permian; dinosaurs appeared and the seas retreated from the GC region for the last time. Mammals and birds appeared; sand dunes swept across the region; the Rockies began to rise; the dinosaurs died out and mammals took over. The canyon began to be carved somewhere in there; volcanoes erupted and poured lava into the canyon. Large furry creatures and vampire bats hung out in GC caves, followed by tourists and river runners...

  A whole lot more happened, too, but you'll just have to read the book...

A Clue to What Some Common Invertebrate GC Fossils Tell Us

Stromatolites - common in several of the Grand Canyon Supergroup formations

“Club sandwich” layer-cake constructions of cyanobacteria, silt and lime, these guys grow in shallow, often hypersaline, warm and sometimes mineral-rich waters. They are lumpy because cyanobacteria are photosynthetic and they seek the sun, growing upward. Some grow faster than others, so they form the lumpy parts. As a side note, they also produce oxygen as a byproduct of photosynthesis, and until they evolved there was no free oxygen in the atmosphere.



Brachiopods – common in the Muav, Temple Butte, Redwall, Toroweap and Kaibab.

These look a lot like clams, but are completely unrelated. Because they have very sensitive filtering mechanisms to get food out of the water, they are good indicators of very clear water, fairly shallow (less than 300 feet or so) to allow light to feed the plants they ate. They liked to anchor themselves on a firm, stable bottom. Brachiopods still exist, but their numbers were hugely reduced at the end of the Permian.

Sponges – common in the Redwall and Kaibab

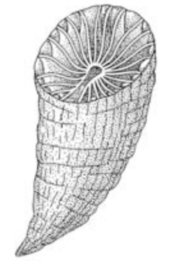
These often look like lumps that stick out of the limestone, sometimes a different color. This is because sponge “skeletons” are often made of silica (quartz) and when they die, that quartz accumulates as blobs of chert, much harder than the surrounding limestone. The primitive multi-cellular animals were often tall and vase-shaped, living on the sea floor and filtering planktonic plants out of the water. They like clear, warm, nutrient-rich water. Sponges are still really common in the oceans.

Crinoids – common in the Muav, Redwall and Kaibab

Related to sea stars, sea urchins and sand dollars, these flower-like animals anchored themselves on a long stem (the pieces are what we find in the canyon) and filtered planktonic plants out of the water column with their anemone-like arms (attached to the head, or calyx). They like clear, warm water with currents to bring the food to them. Crinoids still exist in the oceans, but they’ve gotten rid of the stem and now look like feather dusters attached to corals or rocks.

Horn corals – common in the Redwall and Kaibab

These did not form reefs in the oceans of the Grand Canyon region. Instead, horn corals grew singly, like little ice-cream cones on the sea floor. These guys are predators, like all corals, and they use their stinging “tentacles” to paralyze small fish. They are great indicators of water temperature (in the high 70s to mid 80s), clarity (clear) and depth (less than 300 feet or so). Horn corals still exist, but their place has been taken for the most part by reef-forming corals.



Bryozoans – common in the Redwall and Kaibab

Colonial organisms, these little filter feeders built an apartment house that looked either like a network of sticks or a piece of lace (or Swiss cheese, if you’re so inclined). These animals had the same delicate filtering mechanism as the brachiopods, so they are good indicators of clear water, also warm, shallow and with slight currents to bring food in. Bryozoans still exist in the world’s oceans but they are not as common as they often were in Paleozoic seas.

Fenestella

Nautiloids – Redwall

Related to modern squid and octopus, these chambered shellfish were supreme predators, and were the first real predators in the oceans, before fish evolved jaws and teeth to be very successful at chomping things. They would grow outward, either in a spiral or in a straight cone. As they grew, they would almost seal off the chambers behind them, leaving a tube to connect all the posterior chambers. They would adjust their buoyancy by changing the amount of air and water mixture in those posterior chambers. There are only five species of *Nautilus* left in the world, all the spiral kind, and all in the Micronesia/Philippines/Java area.

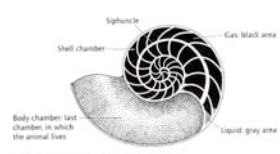
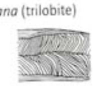


Fig. 9.11 The buoyancy mechanism of *Nautilus*

Rusophycus (trilobite)

Cruziana (trilobite)



Trace Fossils – Common in almost all formation, but especially in the Tapeats, Bright Angel, and Coconino

Worm burrows tell of critters bulldozing dinner from the sediment, some may be dwellings. Trilobites left their resting and moving traces in the mud, probably from digging around for food as well. Arthropod and reptile tracks in the Coconino seem to represent critters on “sand dune highways,” maybe migrating to water.

arthropod