ARBOREAL STROMATOLITES: A 210 MILLION YEAR RECORD

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Stromatolites (from Greek for "stony carpets") are lithified, microbially produced arches, spheres, or domes that can reach over one meter in height. Along with their nonlithified forerunners, microbial mats, stromatolites are widely assumed to have been the dominant form of microbial community life in the Precambrian. Stromatolites are dominated by cyanobacteria that shed their polysaccharide sheaths and move up in search of light in an incremental process (often less than 1 mm per year). The polysaccharide sheaths trap and bind sediment and calcium carbonate and the cyanobacteria provide photosynthate and additional compounds for other bacteria. (Another means of stromatolite growth is via the formation by cyanobacteria of their own carbonate network.) Originally known as "cryptozoans" ("hidden animals") because of their mysteriously biogenic shape, the first stromatolites to be correctly identified as containing and requiring bacteria for their precipitation were entirely marine.

Freshwater stromatolites are also fairly common (Winsborough et al., 1994; DeWet et al. 2002; Whiteside et al., 2003). Fossil lacustrine examples include a ~210-million-year-old record of tree encrusting (arboreal) stromatolites (from 0.1 to +1 m in diameter) from the Newark Supergroup of Eastern North America (Whiteside et al. 2003), and in other age strata primarily in Wyoming (~50 Ma) and in California (~16 Ma).

An analogy may be made between modern mats and stromatolites that inhabit hypersaline and otherwise extreme environments in space and lacustrine stromatolites arising during extreme climatic shifts (Olsen 1996) in time. For example, tufa calcite, stromatolitic coatings of carbonate on branches of trees from the Passaic Formation of the Newark basin have been interpreted to result from the transgression of the lake as low-lying vegetation is submerged. Fossilized arboreal stromatolites have been recovered from Triassic, Jurassic, Eocene, and Miocene lacustrine strata in North America. Cheirolepidiaceous conifers, encased by stromatolites and dated as old as ~210 and ~200 million years, have been uncovered from the Passaic and Towaco Formations of the Newark basin (Figure 1), and tree- and stem-encrusting stromatolites have also been retrieved from the East Berlin Formation in Connecticut and from the Scots Bay Formation in Nova Scotia, both about 200 Ma. Eocene fossils (~50 Ma) from the Laney Member of the Green River Formation in Wyoming (Figure 2) and Miocene forms (~16 Ma) from the Middle Miocene Barstow Formation in California provide more recent examples of "tree-hugging" stromatolites. In

Figure 1 Cross-section of Towaco (~200 Ma) Formation, Newark basin stromatolite from New Jersey. The remnants of the tree in cross section are represented by the dark oblong spearhead in the middle. The concentric stromatolitic rings suggest that this tree, a cheirolepidiaceous conifer, was upright and continued to grow after submergence.

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from: Lowman, M. D. and Rinker, H. B., 2004, Forest Canopies, 2nd ed. Elsevier, Amsterdam, pp. 147-149.

ARBOREAL STROMATOLITES: A 210 MILLION YEAR RECORD–*cont'd*

cyclical environments, as the climate shifts from arid to humid, the trunks and roots of flooded trees serve as temporary habitable zones for the anciently evolved stromatolites. Autoradiography of East Berlin, Towaco, Passaic (Figure 3), and Barstow stromatolites

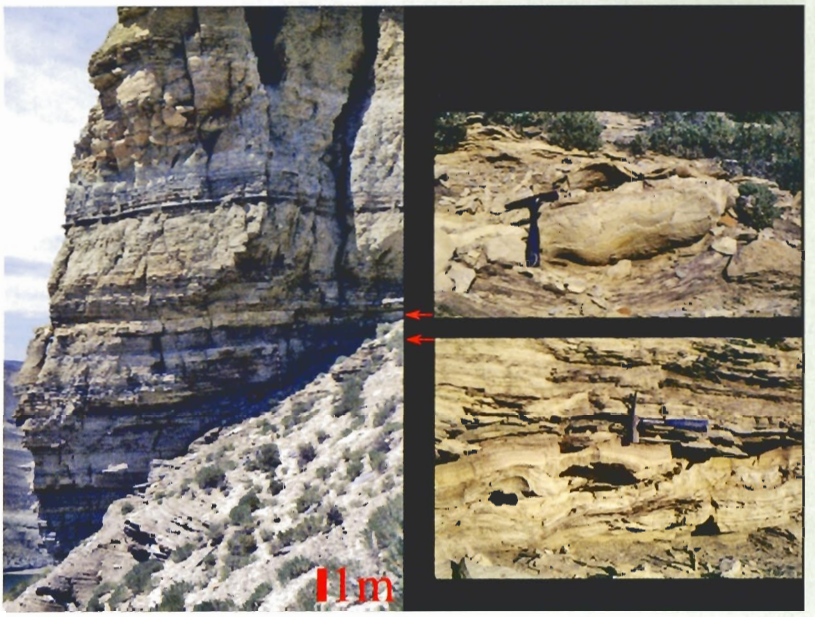

Figure 2 Outcrop from Firehole Canyon in the Laney Member (~50 Ma) of the Green River Formation, Green River Basin in Wyoming. Left (panoramic perspective): Contiguous stromatolitic laminations embedded in cliff face. Upper right (close-up): lobate-shaped stromatolite with lithified remnant of tree trunk visible as dark end of cylinder protruding at right end of rock. Lower right (close-up): in situ photograph of wavy laminated stromatolite with two trees visible in cross-section at each end of photograph (light rings surrounded by concentric layers). Rock hammer for scale. Photograph courtesy of Malka Malchus.

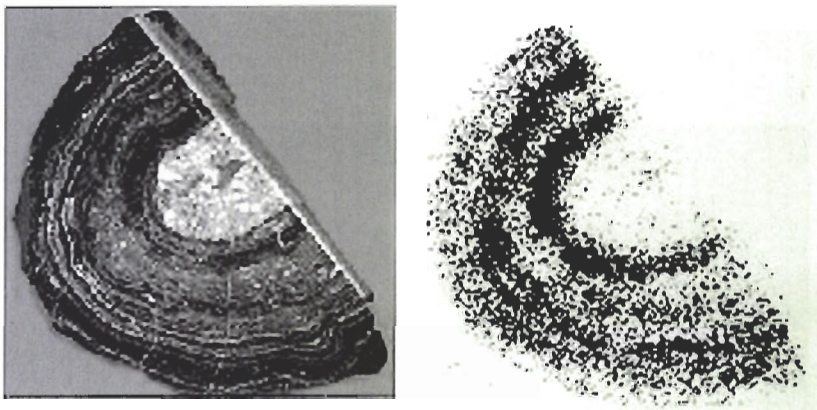

Figure 3 Polished slab of stromatolitic tufa- (porous calcite-) coated branch from the Metlars Member (~210 Ma), Passaic Formation, Newark basin in Pennsylvania. Left: The central area with the light-colored calcite was a branch that provided the nucleus for stromatolite growth. Layers accrued from the center outward. Right:Autoradiograph of polished slab, showing a clear elevated uranium concentration with growth layers (dark areas). Photograph courtesy of Troy Rasbury.

suggests that the bacteria that form the coatings were also involved in uranium mineralization. As the climate becomes more humid, previous desiccated flats are vegetated. As the expanding lake floods these flats, stromatolites encrust the trunks and exposed roots of the drowned vegetation (De Wet et al. 2002) until they too are submerged below the photic zone, knocked down and transported, and/or buried by accumulating muds. These arboreal stromatolites are very similar morphologically to living forms described by Winsborough et al. (1994) in spring-fed lakes and streams of the Cuatre Cienegas basin, Mexico. The 210-milllion-year record of tree-encrusting stromatolites shows that forms of life once thought to be solely marine and mostly ancient can, under extreme environmental conditions, form close associations, in freshwater and in Phanerozoic times, with submerged forest canopies.

References

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