Riding, R. 2008. Marrying stromatolite perspectives: 3500 million years of history and a century of research. Geobiology of Stromatolites, International Kalkowsky Symposium, Göttingen, Germany, October 4–11, 2008. Abstract Volume and Field Guide to Excursions: 29–30. ISBN 978-3-940344-52-6

Marrying stromatolite perspectives: 3500 million years of history and a century of research

Robert Riding
Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996, USA.
(riding@cardiff.ac.uk)

Stromatolites combine an extraordinarily long geological record with an unusual mixture of challenges. How they have formed and changed through time are key areas for research. Approaches to these questions hinge on stromatolite definition, and continuing lack of resolution of this central issue compounds the difficulties. Reflecting on the century since Ernst Kalkowsky introduced 'Stromatolith', a pessimist might emphasize dogma and confusion. An optimist, on the other hand, could highlight significant advances that have laid the groundwork for many fruitful insights. Given their long history, the time period from which stromatolites are viewed is critically important. It is not difficult to regard many Phanerozoic stromatolites as essentially lithified microbial mats. In contrast, many Precambrian examples contain precipitated abiogenic crusts, both with and without microbial mats. The immediate challenge is to marry these dual abiogenic and biogenic perspectives of stromatolites resulting from a century of research.

Regular, even layering, common in Archaean stromatolites, probably reflects significant abiogenic precipitation, and early-mid Proterozoic stromatolites, including Conophyton, commonly show dark-light layers that appear to represent alternations of lithified mat and abiogenic crust. In contrast, Phanerozoic marine stromatolites are characterized by uneven fine-grained layers. These successive developments suggest decline in abiogenic precipitation and increase in lithified mat components through time. Presumably these in turn reflect changes in seawater chemistry and mat growth. Large - metric, even decametric - evenly layered Precambrian cones and domes lack present-day analogues. What factors determined their size and morphology, and promoted alternation of mat and abiogenic precipitate?

Abiogenic precipitation and mat lithification are dependent on carbonate saturation state with respect to CaCO3 minerals. Two important processes promoting carbonate precipitation in mats are sulphate reduction and photosynthesis. These could respectively be largely responsible for clotted/peloidal (spongiostrome) and tubiform (porostromate) microfabrics, and their inceptions could reflect changes in seawater composition. Palaeoproterozoic development of clotted/peloidal fabrics might reflect

increased SO_4^{2-} level. Mesoproterozoic appearance of cyanobacterial sheath calcification could reflect development of CO_2-concentrating mechanisms stimulated by decline in atmospheric CO_2.

Stromatolite shape reflects original synoptic relief, determined by accretion rate relative to adjacent sediment. Low relative accretion rate results in low relief and complex shape; high relative accretion rate results in high relief and simple shape. In this view, mid-Proterozoic increase in morphotypic diversity, e.g., in branched stromatolites, is not a proxy for abundance. Instead it reflects lower synoptic relief due to reduced relative accretion rate. It could reflect reduced microbial growth and/or reduction in synsedimentary lithification.

Phanerozoic development of algal and metazoan reef builders inhibited microbial dome-column formation in favour of less regular reefal crusts, except during Mass Extinction aftermaths and in ecological refuges such as Shark Bay and Lee Stocking Island. Long-term overall decline in microbial carbonate abundance probably mainly reflects decline in seawater saturation state that slowed lithification and therefore accretion. Grazing may have been a subordinate factor so long as microbial mats were well lithified. Fluctuations in seawater saturation state are reflected by changes in microbial carbonate abundance and episodic development of dendrolite and thrombolite fabrics in the Cambrian-Early Ordovician, Late Devonian, and Permian-Triassic. Present-day high metazoan diversity and generally low saturation state result in scarcity of marine microbial carbonates. Diatoms transformed Cenozoic mat communities, significantly enhancing trapping ability, reflected in the formation of coarse-grained columns where stress inhibits metazoan overgrowth, as at Shark Bay and Lee Stocking Island. The coarse and crudely layered fabrics prominent in some of these columns are not closely comparable with most ancient stromatolites.

From this perspective, stromatolites emerge as abiogenic, biogenic, and combinations of the two. Their alterations in shape, size, fabric and abundance through time archive significant changes in atmospheric composition, seawater chemistry, mat evolution and biotic interaction. The key to ancient stromatolites lies in present-day examples. The key to present-day ones resides in the past.