Controls on Proterozoic stromatolites: CO_2 drawdown, style of photosynthesis, and continental assembly

ROBERT RIDING[1], FABIO TOSTI[2]

[1]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA (rriding@utk.edu)

[2]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA (ftosti@utk.edu)

The rise and fall in diversity of branched columns between ~1500 and 500 Ma is a motif for stromatolite history. But what caused it? The protracted decline, from ~1.25 to 0.5 Ga, which has attracted most attention, has been variously attributed to increase in metazoan competition and reduction in seawater carbonate saturation state. The steeper increase in diversity, between ~1.5 and 1.25 Ga, remains enigmatic. We suggest it reflects widespread development of fine-grained agglutinated stromatolites in response to increased abundance of carbonate mud. Weakly lithified mats that trapped the mud constructed low relief columns. Their interaction with adjacent sediment resulted in frequent changes in column width, branching and bridging. This dynamic process generated a wide variety of morphotypes. These are enshrined in the large number of mid-late Proterozoic stromatolite taxa, many of which are low-relief columns. The increased abundance of carbonate mud that was instrumental in this development reflects water column 'whiting' precipitation induced by the response of cyanobacterial photosynthesis to decline in atmospheric CO_2 by inducing CO_2-concentrating mechanisms (CCM). CCM utilize bicarbonate as an alternative source of inorganic carbon and, as a result, promote $CaCO_3$ precipitation in the water column. Lower CO_2 levels, that triggered widespread 'whitings' by ~1.45 Ga, probably reflect prolonged supercontinent development that commenced with Nuna/Columbia assembly. This critical interval in stromatolite development is preserved in the classic Jixian Section of late Paleoproterozoic to mid-Mesoproterozoic sediments in northern China. The 1.45 Ga Tieling Formation near Jixian is an early example of well-preserved fine-grained agglutinated stromatolites. We conclude that key features of the Proterozoic history of stromatolite development reflect interconnected extrinsic and intrinsic controls that link the biosphere to all elements of the geosphere.