

A Sideways View of Stromatolites: Complexity Metrics for Stromatolite Laminae

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ABSTRACT

Stromatolites offer a unique window into 3.5 billion years of evolution of the microbial communities that built them within the context of an evolving Earth. Our interest is not in the microbial life or their external matrix as independent entities, but the appearance and evolution of complexity itself within this biogeological system. We adopt the canonical definition of complexity as the emergence and detection of previously unseen properties (structures, functions, information), and we propose that the defining emergent property of stromatolites apparent to the human expert eye is the lamination.

To develop a quantitative complexity metric for stromatolites, we must ask what makes it possible for the human brain to perceive lamination? Our visual system operates optimally as a difference machine rapidly identifying variations in signal intensity and redundancy in neighboring regions. In stromatolites, such differences are detected by first scanning parallel to the growth surface and then placing layers in context by scanning orthogonal to that surface. We propose that the fundamental metric for stromatolite complexity resides in the laminae themselves and that easily measured differences in luminance, variability, and redundancy between alternating laminae is an emergent feature of stromatolite complexity. The metrics calculated for laminae in photomicrographs revealed significant differences between putative biotic/abiotic laminae. The statistical indices calculated can contribute to stromatolite recognition, description, and classification. The indices are easily calculated in the laboratory or in the field on personal computers. We propose that such statistical information metrics be included as a standard component in the description of extant and fossil stromatolites.

Keywords: Stromatolites, complexity, emergent properties, quantitative metrics

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