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Keeping the baby in the bathwater: Diagnostic morphological biosignatures for ancient to modern stromatolites

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Debate continues over the use of rock textures to support biogenicity of ancient stromatolites[1], with claims they represent "suspicious biomarkers"[2] despite >100yr of accumulated knowledge that stromatolites are biological constructs[3]. For example, the biogenicity of well-documented stromatolites from the 3.48Ga Dresser Formation, Australia – widely regarded as the oldest, most convincing evidence of life[4,5] – is still debated[6]. Partly, this debate continues because most stromatolites (of any age) lack microfossils or preserved biomolecules, but also because some abiogenic structures mimic stromatolite characteristics (branching structures, wrinkly laminations)[7,8]. But are we in danger of throwing the baby out with the bathwater if all stromatolites are classified as "suspicious biomarkers"?

Here, we emphasize a commonly overlooked criterion for biogenicity that applies to a range of stromatolite forms in diverse environments across the geological record; specifically the recognition of interference between two demonstrably contemporaneous processes: 1) purely abiological, relating to the geological/environmental context (e.g., current-generated rippled sediment); and 2) biological, relating to microbial stromatolite growth dynamics, including biofilm rheology and the microbially-induced trapping/precipitation of grains/minerals. The key is to identify a textural - and commonly also compositional - contrast between a stromatolite and its surrounding, contemporaneous, sediment[9-11]. Examples are provided for living to recently fossilized Shark Bay stromatolites, Holocene microstromatolites in siliceous sinter, and Proterozoic to early Archean examples from the Pilbara and Greenland, using outcrop and petrographic studies and 3D computational X-ray tomography. Critically, this criterion correctly identifies abiogenic stromatolite mimics, as these have no contrasting sedimentary matrix.

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