

MICROBIALITE MORPHOLOGY AND DIVERSITY IN A LOWSTAND FRINGING REEF, OFFSHORE MOZAMBIQUE

William Wright, Gregor P. Eberli, Ralf Weger, and Paulina Manekas

KEY FINDINGS

- Extensive microbialite development is documented throughout a 65m core of a Last Glacial Maximum (LGM) fringing reef offshore Mozambique
- Five microbialite classes are identified, including laminated, digitate, microbialite-coated debris, structureless, and intraskeletal/boring-filling forms
- Microbialites occur as coating agents, cavity-fillers, and encrusting binders of reef debris

BACKGROUND

Microbialites, organosedimentary structures formed by microbial communities, are increasingly recognized as important components of lowstand reef successions. Volumetrically significant microbialite development has been documented in Holocene reef cavities, such as those in Tahiti (Montaggioni and Camoin, 1993; Camoin and Montaggioni, 1994), and in both fossil and modern reef frameworks (Riding et al., 1991; Riding, 2011). Thick microbialite successions recovered from IODP Expeditions 310 (Tahiti) and 325 (Great Barrier Reef) have been interpreted as forming alongside coral growth or shortly after deposition (Westphal et al., 2010; Seard et al., 2011; Braga et al., 2019). Microbialite formation has been attributed to a variety of environmental influences, including shifts in alkalinity, nutrient availability, and microbial activity such as sulfate reduction (Camoin et al., 2006; Heindel et al., 2010, 2012).

An initial description and interpretation of the microbialites in this offshore Mozambique core was conducted by Tomchovska et al. (2022), who found that microbialites comprised approximately 18.3% of the interval examined in Core Section 25. These microbialites occurred as crusts, sediment-binding cements, and pore-filling micrite. Crusts reached thicknesses of up to 6 cm and were commonly observed as a secondary encrusting phase, following an initial framework coating by crustose coralline algae (CCA). Mineralogical analysis indicated the microbialites were primarily composed of high-magnesium calcite, with up to 33.8% aragonite attributed to bioclasts and cement. In the present study, we describe and classify the microbialite fabrics observed throughout the full 65-meter core.

DATA SET AND METHODS

Core ES-103-BH, a 65-meter-long was selected from a ten-core regional dataset for detailed microbialite analysis. Following slab-cutting and high-resolution photography, lithologic descriptions were compiled through visual inspection of slabs, petrographic thin sections, and bulk sediment samples. Emphasis was placed on identifying microbialite occurrences and associated substrates.

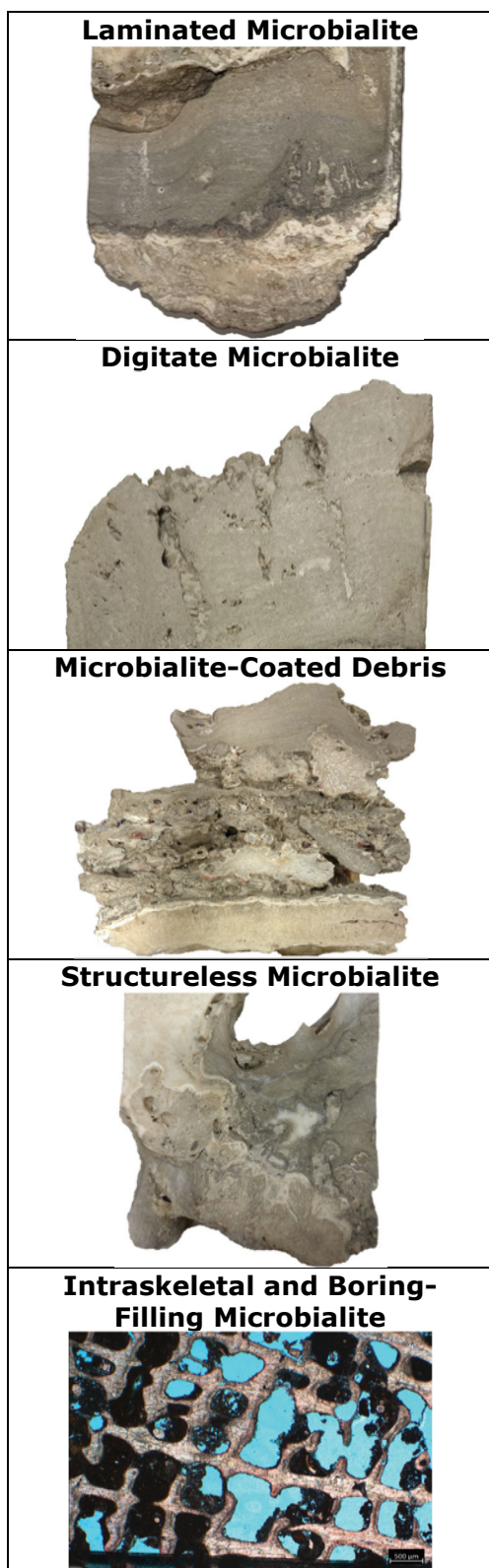


Fig. 1 Representative examples of the five microbialite types identified in the Mozambique fringing reef core

Core sheets were digitally compiled and integrated to establish continuity and identify intervals of microbial encrustation across facies transitions. Microbialite morphologies were classified at the mesoscale following the criteria of Braga et al. (2019), which emphasize macroscopically visible structures such as lamination, digitate projections, micritic coatings, and structureless fabrics.

OBSERVED MICROBIALITE MORPHOLOGIES

Five distinct microbialite types (Figure 1) were identified in the core: laminated, digitate, microbialite-coated debris, structureless, and intraskkeletal/boring-filling forms.

Laminated Microbialite:

Laminated microbialite occurs as thin, laterally extensive micritic coatings on coral and coralline algal substrates, typically no more than 2mm thick. These coatings display fine internal layering with subtle color and thickness variations, often oriented parallel to the substrate. Laminated microbialites commonly overlie encrusting coralline algae (CCA) and form part of a consistent encrustation sequence observed across multiple facies, particularly in the reef crest environment.

Digitate Microbialite:

Digitate structures are rare but occur in isolated zones within reef crest intervals. They appear as upward-projecting lobes with irregular branching and finger-like morphologies, ranging from a few millimeters to over a centimeter in width. These structures typically overlie laminated or structureless crusts. The digitate morphologies reflect localized microbial accretion.

Microbialite-Coated Debris:

This type of microbialite is characterized by skeletal fragments (coral, CCA, and bioclasts) that are encrusted by thin, micritic microbialite layers. These coatings are generally less than 5mm thick and conform to the geometry of the underlying grain, giving

a smooth or irregular rind-like appearance. This form is most abundant in reef front to reef crest facies where coral and skeletal debris are loosely packed, and microbial coating likely contributed to early stabilization and partial lithification.

Structureless Microbialite:

Structureless microbialite occurs as dense, micritic infillings that lack internal lamination or visible organization. These deposits appear in interstitial voids, framework cavities, and surrounding heavily encrusted debris. The fabric is commonly homogeneous and varies in color from light gray to brown. Structureless microbialite commonly contributes to intraskeletal and boring-filling fabrics. Along with microbialite-coated debris, this is the most widespread microbialite fabric, spanning numerous facies.

Intraskeletal and Boring-Filling Microbialite:

Intraskeletal microbialite appears as fine micritic infill within large coral skeletons, gastropod shells, and boring traces (e.g., *Lithophaga*). These infillings are often structureless but can exhibit a range of microbialite microfabrics, including clotted, peloidal, and dense homogeneous micrite (Tomchovska et al., 2022). They are especially common in the reef crest facies in massive coral heads, where microbial micrite has partially or completely occluded borings and intraskeletal cavities.

SIGNIFICANCE AND IMPLICATIONS

The identification of five distinct microbialite morphologies within the fringing reef core offshore Mozambique underscores the complexity of microbialite development during lowstand reef growth. These structures occur as framework elements, sediment-binding agents, and cavity-fillers, revealing their multifaceted role in stabilizing reefal substrates and enhancing carbonate accretion under restricted accommodation. The widespread distribution of microbialites throughout the core suggests persistent microbial activity across multiple reef growth phases, including early framework initiation, periods of reduced coral growth, and cavity infilling.

These findings provide a unique window into microbialite–coral–sediment dynamics in a lowstand reef setting, where conditions may have favored microbial encrustation. The absence of subaerial diagenesis and meteoric overprinting in this offshore core allows direct insight into early lithification processes and microbial textures preserved in situ. This dataset offers a valuable reference for interpreting microbialite fabrics in both fossil and modern reef systems and lays the groundwork for future geochemical and chronological analyses aimed at resolving the timing, conditions, and biogeochemical drivers of microbialite formation during the Last Glacial Maximum.

REFERENCES

- Braga, J. C., Puga-Bernabéu, Á., Heindel, K., Patterson, M. A., Birgel, D., Peckmann, J., Sánchez-Almazo, I. M., Webster, J. M., Yokoyama, Y., & Riding, R. (2019). Microbialites in last Glacial Maximum and deglacial reefs of the Great Barrier Reef (IODP Expedition 325, NE Australia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 514, 1–17. <https://doi.org/10.1016/j.palaeo.2018.10.007>

- Camoin, G. F., & Montaggioni, L. F. (1994). High energy coralgall-stromatolite frameworks from Holocene reefs (Tahiti, French Polynesia). *Sedimentology*, 41(4), 655–676. <https://doi.org/10.1111/j.1365-3091.1994.tb01416.x>
- Camoin, G., Cabioch, G., Eisenhauer, A., Braga, J.-C., Hamelin, B., & Lericolais, G. (2006). Environmental significance of microbialites in reef environments during the last deglaciation. *Sedimentary Geology*, 185(3–4), 277–295. <https://doi.org/10.1016/j.sedgeo.2005.12.018>
- Heindel, K., Birgel, D., Brunner, B., Thiel, V., Westphal, H., Gischler, E., Ziegenbalg, S. B., Cabioch, G., Sjövall, P., & Peckmann, J. (2012). Post-glacial microbialite formation in coral reefs of the Pacific, Atlantic, and Indian Oceans. *Chemical Geology*, 304–305, 117–130. <https://doi.org/10.1016/j.chemgeo.2012.02.009>
- Heindel, K., Birgel, D., Peckmann, J., Kuhnert, H., & Westphal, H. (2010). Formation of DEGLACIAL microbialites in coral reefs off Tahiti (IODP 310) involving sulfate-reducing bacteria. *PALAIOS*, 25(10), 618–635. <https://doi.org/10.2110/palo.2010.p10-032r>
- Montaggioni, L. F., & Camoin, G. F. (1993). Stromatolites associated with coralgall communities in Holocene high-energy reefs. *Geology*, 21(2), 149. [https://doi.org/10.1130/0091-7613\(1993\)021<0149:sawcci>2.3.co;2](https://doi.org/10.1130/0091-7613(1993)021<0149:sawcci>2.3.co;2)
- Riding, R., Martin, J. M., & Braga, J. C. (1991). Coral-Stromatolite Reef Framework, Upper Miocene, Almería, Spain. *Sedimentology*, 38(5), 799–818. <https://doi.org/10.1111/j.1365-3091.1991.tb01873.x>
- Riding, Robert. (2011). Reefal microbial crusts. *Encyclopedia of Earth Sciences Series*, 911–915. https://doi.org/10.1007/978-90-481-2639-2_112
- Seard, C., Camoin, G., Yokoyama, Y., Matsuzaki, H., Durand, N., Bard, E., Sepulcre, S., & Deschamps, P. (2011). Microbialite development patterns in the last deglacial reefs from Tahiti (French Polynesia; IODP Expedition #310): Implications on reef framework architecture. *Marine Geology*, 279(1–4), 63–86. <https://doi.org/10.1016/j.margeo.2010.10.013>
- Tomchovska, I., Eberli, G., Oehlert, A., & Klaus, J. (2022). Assessing contemporaneous formation of microbialites and corals in a post-glacial maximum reef: offshore Mozambique. M.S. thesis, University of Miami.
- Westphal, H., Heindel, K., Brandano, M., & Peckmann, J. (2009). Genesis of Microbialites as contemporaneous framework components of deglacial coral reefs, Tahiti (IODP 310). *Facies*, 56(3), 337–352. <https://doi.org/10.1007/s10347-009-0207-3>