

CHANGES IN ABUNDANCE AND DIVERSITY OF MICROBIALITES OF A FRINGING REEF, OFFSHORE MOZAMBIQUE

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KEY POINTS

- The most diverse and abundant microbialites grew during the early deglaciation and the rapid increase in water depth.
- Microbialite diversity is significantly different before deglaciation, with MCD and layered morphologies being the most abundant.
- Several types of micritic cements—interpreted as induced by microbial activity—are the dominant early cements in the reef framework.
- There is no difference in stable-isotope signatures among the different microbialite types, indicating that microbialite morphology and color are not diagnostic for environmental change.

PROJECT RATIONALE

A 65 m core (ES-103-BH) of a reef that grew during the Last Glacial Maximum (LGM) recovered a suite of diverse microbialites with distinct morphologies and colors that are intimately tied to the coral framework. The microbialite acts as a cavity filler, a sediment binder, an encrusting agent, and an overall stabilizer

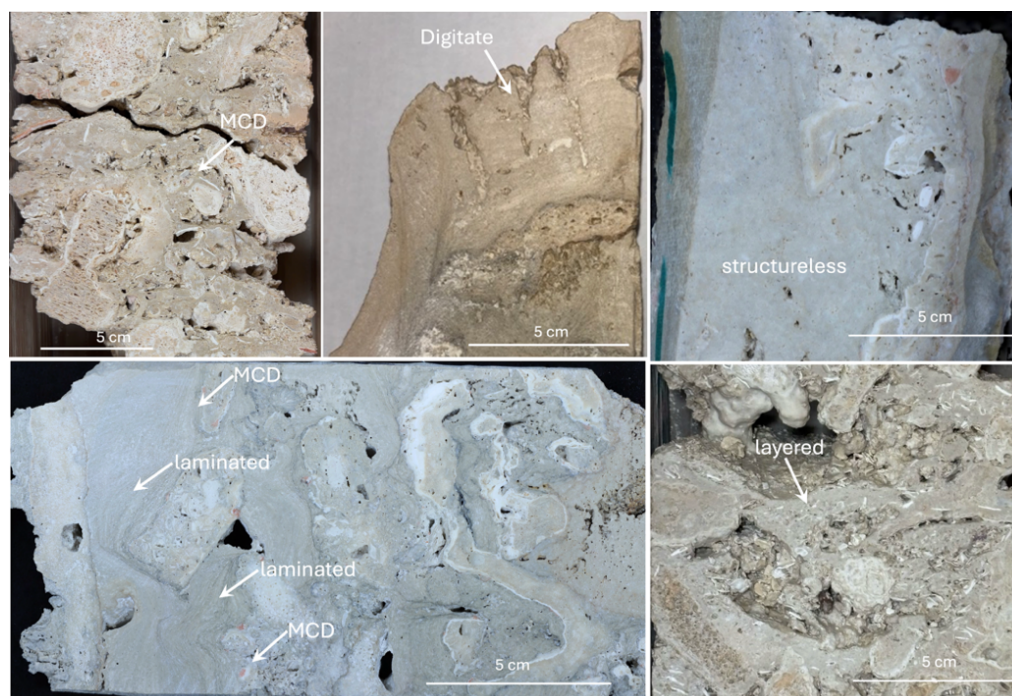


Figure 1: Examples of five microbialite types identified in the Mozambique reef core. They consist of microbially coated debris (MCD), structureless, digitate, laminated, and layered.

throughout the core. Prior work showed that microbialites in deglacial reefs in Tahiti developed a few hundred years after corallgal communities (Seard et al., 2011). In all recovered LGM cores, the microbialites have several distinct morphologies and colors (Braga et al., 2019). In the Mozambique core studied here, we have recognized five microbialite morphologies (Fig. 1). In addition, micritic cement types are ubiquitous within the reef framework (Fig. 2).

Microbialites are typical in LGM reefs and might be tied to the environmental conditions that existed during times of lowered sea level. Core ES-103-BH recovered rocks from 34.0 to 14.1 ka, covering the entire LGM and the early deglaciation. We investigate the stratigraphic distribution of the microbialites and assess whether microbialite morphologies change from LGM to the deglaciation. Coral reefs of the LGM might serve as archives of reef responses to shifts in ocean chemistry resulting from sea-level fluctuations. By combining a detailed classification of specific microbialites and high-resolution stable-isotope geochemistry, we test the hypothesis that microbialite morphologies and colors are indicators of environmental change.

METHODS

Multiple steps have been defined to test the hypothesis that microbialite morphologies and colors are indicators of environmental change. Meticulous core logging and high-resolution core photography are essential for defining each morphology and color. In a first step, we logged the morphology of the microbialites in the core to assess the stratigraphic distribution. With the core logs and photos, color-coded maps like the original study's core composition figure (Tomchovska et al., 2022) were drawn for selected intervals, where each color indicates a distinct morphology. Based on the microbialite maps, samples were taken from each location while defining the color of each sampling location. A Delta Q Isotope Ratio Mass Spectrometer was then utilized to determine the stable carbon ($\delta^{13}\text{C}$ VPDB) and oxygen ($\delta^{18}\text{O}$ VPDB) isotope values of the microbialite samples.

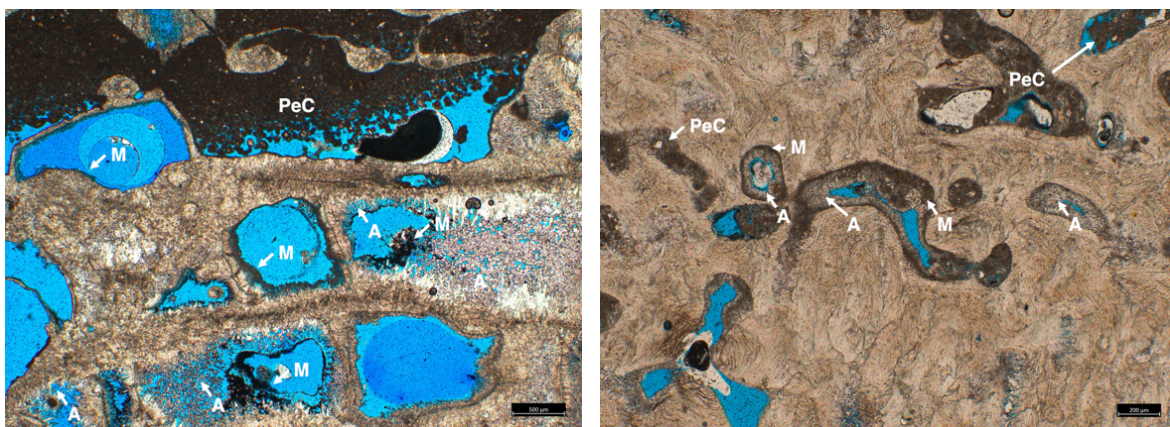


Figure 2: Photomicrographs illustrating the most common intraskeletal micritic cements. PeC = peloidal cement, often found in larger pores. M = micritic rind often lines pores and is the base for aragonitic needle cement.

RESULTS

Five types of microbialites are identified in the core. They consist of microbially coated debris (MCD), structureless, digitate, laminated, and layered. Four of these microbialite types are described by other authors (Braga et al., 2019), while the layered microbialite (L₂ in Figure 3) that is associated with platy corals in the fore reef environment is unique to our data set. These layered microbialites occur in the core below 32 m in sections 4 and 5. Microbially coated debris (MCD) is interwoven throughout these intervals. MCD is the most abundant microbialite type and is present throughout the core, with large concentrations covering pebble-sized rudstones in lithologic sections 1 (drowned reef), 4 (fore reef slope), and frame/bindstone in lithofacies 4. Structureless, digitate, and laminated microbialites are concentrated in sections 1, 2, and 3 (the drowned reef and reef crest), which are dominated by pebble-sized rudstones and frame/bindstones. The slope section below 55 m in the core does not have any macroscopically visible microbialites. In thin sections, rare intraskeletal micritic cement is visible, indicating that some microbial activity occurred even in the slope section.

Intraskeletal and boring-filling micritic cements are abundant throughout the core. We identified the six micritic cements defined by Marshall and Davies (1981) in the thin sections. The most common cement in larger pores is peloidal cement that partly or completely fills the pores (Fig. 2). Micritic rinds are generally the first cements in corals and often are the base for crystalline aragonite cement. In some cases, aragonite cement is followed by another generation of micritic cement.

When evaluating the microbialite abundance and diversity with regard to sea-level change, a clear pattern is recognized. Microbialite morphology and

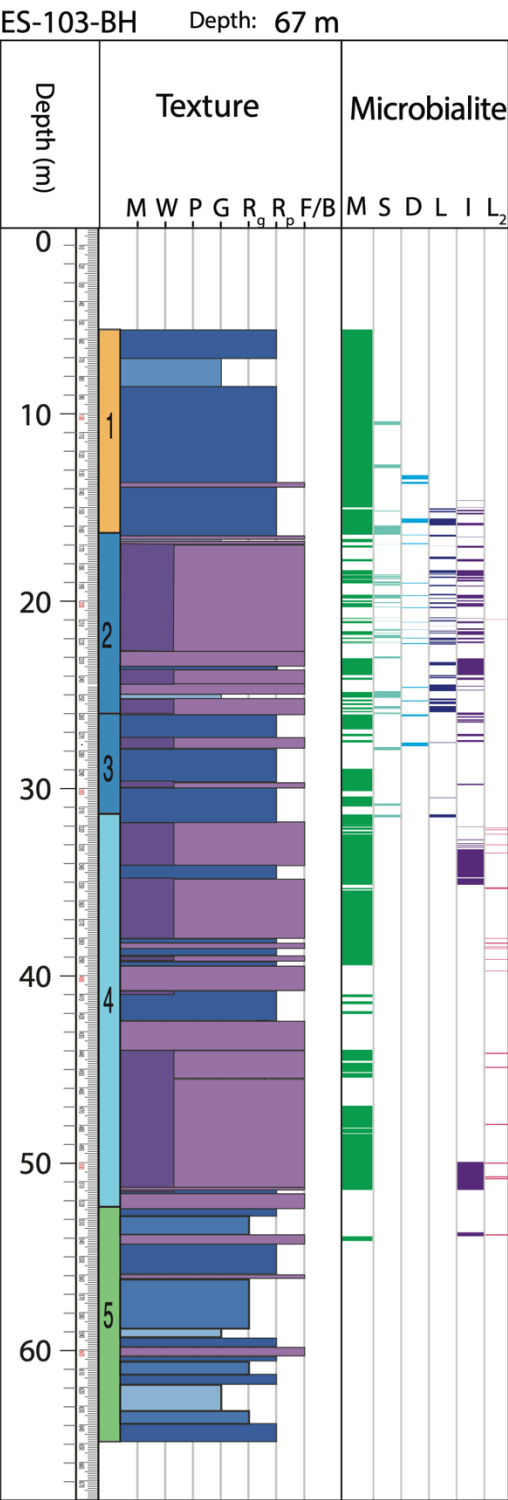


Figure 3: Microbialite map of core ES-103-BH alongside a map of the core's texture. Key: M: Microbially coated debris (MCD); S: Structureless; D: Digitate; L: Laminated; I: Intraporal; L₂: Layered.

diversity significantly change with the beginning of the deglaciation when enough accommodation space is produced for the development of a barrier reef. This change is documented by the stark shift of microbialite diversity at the lithologic boundary 3/4, above which the corals are of reef crest affinity. Before deglaciation, the microbialites on the fore reef slope are dominated by MCD and layered microbialites, whereas after deglaciation begins, digitate, structureless, and laminated morphologies begin to weave their way throughout the sporadic sections of MCD.

Stable carbon ($\delta^{13}\text{C}$ VPDB) and oxygen ($\delta^{18}\text{O}$ VPDB) isotope values of the microbialite samples show no correlation between color and morphology, let alone color or morphology being indicative of any external or internal environmental changes, rejecting the hypothesis that morphology and color are indicators of environmental change.

SIGNIFICANCE

Microbialites in deglacial reefs in Tahiti (Seard et al., 2011), the Great Barrier Reef (Braga et al., 2019), and offshore Mozambique are defined as nearly synchronous accretional microbialites, a key structural element to the stability of the coral reef. Although it is commonly assumed that the different morphologies occur throughout the core, this study reveals that morphologies change with sea level. Microbialite morphology and diversity are low during the LGM but increase dramatically with the onset of deglaciation and concomitant sea-level rise. This change in microbialite abundance and diversity during the early deglaciation/transgression might be related to increased upwelling of nutrients during these times. Transgressive microbialites are important for the stability of the reef and fore reef slope and likely for preservation of primary porosity.

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