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Inferences from the cooccurrence of modern stromatolites with metazoans using geobiological and geochemical approaches

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The modern scarcity of laminated and accreting biofilms is at least partially attributed to the Cambrian radiation of metazoan diversity and subsequent evolution of burrowing and grazing animal behaviours which resulted in the active bioturbation and homogenisation of soft sediment surfaces. Consequently, microbial mats that trap and bind sediment or precipitate calcium carbonate to form microbialites, and especially their layered forms, the stromatolites, are rare in most modern aquatic environments. In addition to the evolution of metazoan bioturbators other factors have also contributed to the modern rarity of microbialites, such as depleted carbonate saturation levels. In South Africa, Western Australia and the British Isles a network of supratidal spring-fed living microbialite ecosystems (SSLiME) have been described within the past decade or so, occurring at the interface of fresh carbonate-rich groundwater discharging above the highwater mark at the coast. These support a range of invertebrates with active burrowing and grazing lifestyles, including typical bioturbators such as polychaetes, arthropods and gastropods. However, and perhaps counterintuitively, the presence of these macrofauna does not preclude the formation of well-laminated and subsequently preserved stromatolites. As part of a multidisciplinary project, here we present key findings from research conducted on these SSLiME to reveal geobiological and geochemical factors that restrict potential grazing and burrowing pressures placed by metazoans living within the microbialite matrix. We do this using a combination of in situ observations, dietary tracers and experimental manipulations. Evidence suggests that the metazoans able to tolerate the dynamic salinity extremes within this environment might be promoting microbialite persistence, through for example preferentially grazing upon other autotrophs that might otherwise outcompete the biofilm. We also show that the metazoans might be facilitating sediment accretion under certain conditions. These observations have valuable implications for interpreting the fossil record in terms of the interplay between metazoan-microbialite coexistence or exclusion, for example during major evolutionary transitions following radiation events.