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Nanoscale evidence for microbial mineralization of 2.7 Ga stromatolites

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The macroscale morphology of Archean stromatolites has been used as evidence of early microbial ecosystems. But as Archean stromatolites only rarely contain fossil microbes, their biogenicity is tacitly assumed on the basis of macroscopic morphological comparisons with modern structures. Biogenetic definitions, however, require microscopic examination of suspected stromatolites. We obtained an unique collection of pristine samples from a diamond drillhole that intersected the 2.7Ga Tumbiana Formation, Australia (Pilbara Drilling Project). We report the occurrence of micron-sized globules of organic carbon intimately associated with the host micritic carbonate. Scanning Transmission X-ray Microscopy (STXM) analysis revealed that these organic globules are composed of organic carbon with aromatic, aliphatic and carboxyl functional groups. High Resolution Transmission Electron Microscopy (HRTEM) analysis revealed that the organic material occurs in intimate association with clustered, 50-200 nm rounded bodies of aragonite. These nano-aragonite aggregates show striking similarities with nano-carbonate spheroids associated with microbial cells and polymers in modern microbialites. The organic globules are moreover cell-like. They might have been preserved owing to their encapsulation in carbonates. The organic preservation pathway of these globules will be discussed based on our systematic study of the distribution and composition of the organic matter in the Tumbiana stromatolites.

Our results indicate that Tumbiana stromatolites were likely formed via in-situ microbial lithification. They also extend the geologic record of aragonite back more than 2,300 million years.