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Microbial Carbonates of Shaybarah Island, Central Red Sea, Saudi Arabia—A unique assemblage of Stromatolites, Polygonal Tepees and Beach Rocks

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Microbes were the dominating carbonate forming marine biota in the Archean and Proterozoic forming stromatolites and other microbialites. During the Phanerozoic their importance in producing carbonates has been reduced to niche occurrences usually found in challenging environments, such as eu-/aphotic platform slopes, hypersaline marine settings and alkaline lakes. However, more recently the possible agency of microbes in producing carbonates and carbonate rocks such as whitings, ooids and beachrocks has received renewed attention.

We report the discovery of microbially derived limestones in the NE Red Sea on Shaybarah Island, Al Wajh carbonate platform, KSA. Stromatolites, beachrocks and giant polygonal tepees forming in close proximity to Ech other all exhibit convincing evidence for their creation/lithification through microbial activity. Based on satellite and drone surveys calibrated by site surveys, these carbonates cover an area exceeding 55,000 m^2 in a supratidal to very shallow subtidal setting on a paleo-reef flat facing the open sea. The setting and environmental conditions are overall normal marine. Marine biota such as grazing cerithids as common.

Stromatolites occur as elongated rhomboidal structures up to 10 cm in height and low relief (<5 cm) irregular shaped tabular sheets. The rhomboidal intertidal stromatolites are pustular on the

outside and laminated internally. X-ray CT scanning of the stromatolite samples showed moderately well laminated, millimeter scale, lithified layers potentially representing alternating modes of sedimentation and growth. Beach rocks form in the high intertidal zone adjacent to the stromatolite and tepee fields. Aside typical beach rock features of inclined lamination they occur as highly friable and more lithified varieties. The tepees cover the largest area. They have formed in a well-cemented layer of shallow marine, bioclastic sand to gravel-sized sediments composed predominantly of coral, red algae, benthic foraminifera, bivalve and gastropod debris that overlie a pene-planed paleo-reef flat. Individual teepees are composed of chaotically superimposed rugged slabs reaching 3-10 cm in thickness. Tepee ridges range in height from 10-50 cm. Tepees are arranged along larger structures of well-defined polygonal shapes. Using satellite and drone data the dimensions of polygons range in diameter from 5 m to 55 m (n=100) with the majority having a diameter of 10-25 m (n=69).

Scanning Electron Microscopy (SEM) reveals that stromatolites, beach rocks and tepees contain heavily bored carbonate grains, calcified tubes of filamentous cyanobacteria, extensive mucoid sheets and spider-web like organic matter of extracellular polymeric substance (EPS). Carbonate precipitates of sub-micron size equant crystals and elongated aragonite needles, either occurring as single rods or in mashes, are recognized as cements. Metagenomics of bacteria diversity show that cyanobacteria dominate the surfaces, while heterotrophic bacteria are the main component in deeper layers.

Samples from multiple transects and two boreholes were collected for age dating, petrographic and geochemical analysis. Stromatolites and beachrocks form at present, while based on environmentally corrected C^{14} age data tepees are somewhat older with an age of between 3000 to 1000 yr B.P.

Research is continuing on the environmental conditions, aerial distribution, and chemical composition and in particular the microbial communities, their diversity and nutrient cycling.