Microbial Mat Induced Sedimentary Structures (MMISS): An Indicator of Topography

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Microbes are a significant component of sedimentary environments. Under favorable conditions (e.g., reduced grazing, availability of water) they colonize sediment surfaces to produce a mat-like layer that is composed of cyanobacteria, bacteria, fungi, algae, diatoms, etc.; they also incorporate sediment grains. Microbial mats are common in supratidal to intertidal areas of tidal flats, where grazing is restricted by the high salinity and fluctuation between subaerial and subaqueous conditions. The filamentous meshwork of the microbes, along with the sticky EPS (extracellular polymeric substance) secreted by the micro-organisms, enhances the stability and cohesiveness of sediments. Sediment bodies are also affected by the interaction between the microbial growth and sedimentation. As a result, unique sedimentary structures are formed that are called microbial mat induced sedimentary structures (MMISS).

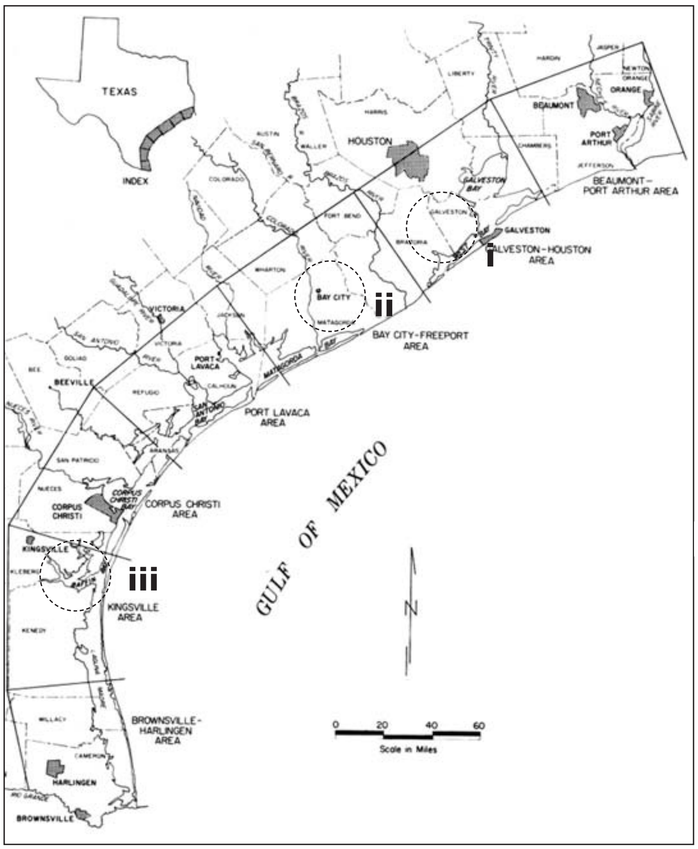

Figure 1 Map of the Texas coast (Modified after "Environmental Geologic Atlas of Texas Coastal Zone," BEG). The circles in dashed lines show the field areas. Locations i and ii are the siliciclastic settings and the location iii is the carbonate.

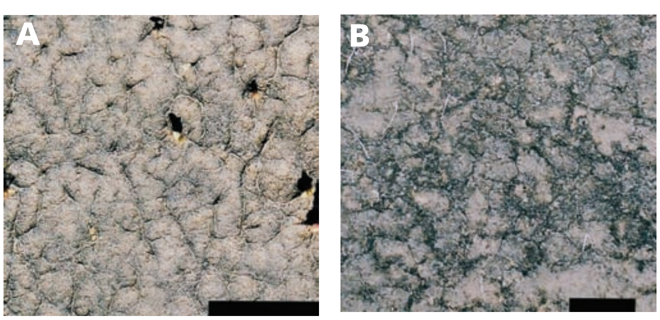

Figure 2 Reticulate-surfaces. Reticulate surfaces on modern siliciclastic sediment (A), Follet's Island, Texas, (B) carbonate sediment surface, Laguna Madre, Texas. Scale bars = 3 cm and 6 cm for A and B, respectively.

Siliciclastic-MMISS were studied on the modern wind tidal flats at the back of Follet's Island and Matagorda Peninsula of the Texas coast (Fig 1). Fine sand- and silt-sized siliciclastic sediments dominate those tidal flats, which are commonly covered by thick microbial mats. Carbonate-MMISS were observed on the tidal flats of Laguna Madre, Texas. The types and distribution of MMISS formed on siliciclastic and carbonate depositional environments are similar.

The most common types of the MMISS include reticulate surfaces, mat cracks, gas domes and sieve-like surfaces. Horizontal growth of the microbial filaments generates a reticulate fabric on sediment surfaces (Fig 2). Gas domes are produced when mat layers bulge up due to the pressure of gas trapped below

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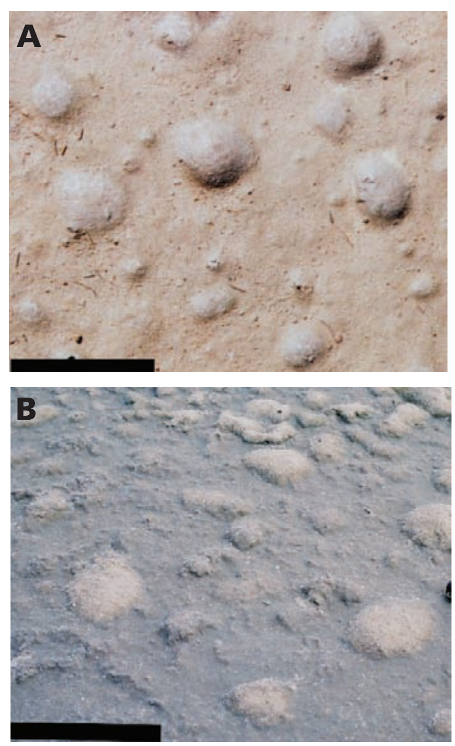

Figure 3 Gas domes on modern sediment surfaces. (A) Siliciclastic sediment surface, Follet's Island, Texas, (B) carbonate sediment surface, Laguna Madre, Texas. Scale bars = 6 cm.

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the impermeable mat covers (Fig 3). Photosynthetic mats release oxygen bubbles into the overlying water (Fig 4). Such bubble morphologies may be partially preserved by microbial growth or salt precipitation surrounding the bubbles, giving rise to sieve-like surfaces (Fig 5). Desiccation of sediment-mat layers results in mat cracks in which the cracked polygons show curled-up peripheries due to differential shrinkage between the top and bottom surfaces of the mats. Thus, mat cracks differ notably from mud cracks (Fig 6).

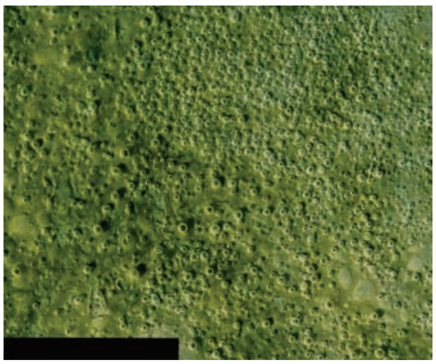

Figure 4 Gas bubbles in water overlying a living, photosynthetic mat. Scale bar = 5 cm.

A strong correlation is recognized between the MMISS and their depositional environments in both of the field areas. Observations indicate that reticulate surfaces are dominant toward the higher part of the tidal flats whereas mat cracks are more common in the lower portions. Four topographic levels were identified based on the MMISS assemblages, starting from the supratidal zones and proceeding downward to the intertidal zones (Fig 7). Level-I is characterized by a sparse reticulate surface. Level-II is dominated by gas domes and reticulate surfaces. Mat cracks along with sparse reticulate surfaces are present on level-III whereas level-IV is characterized by thick mats, larger polygons of mat cracks and sieve-like surfaces.

Availability of water is the most important factor that controls the proliferation of microbial mats and distribution of the resultant MMISS. Therefore, the boundaries between any two of the above-mentioned topographic levels, characterized by different MMISS assemblages, are closely associated with the boundaries between the tidal zones.

This study demonstrates that the influence of microbial mats on sediments is similar for siliciclastic and carbonate settings; MMISS are therefore equally significant in both of the settings with regard to the interpretation of the depositional environment. Finally, it confirms that the distribution of MMISS can be potentially useful in detection of subtle changes in topography and water depth regardless of the type of sediment. ■

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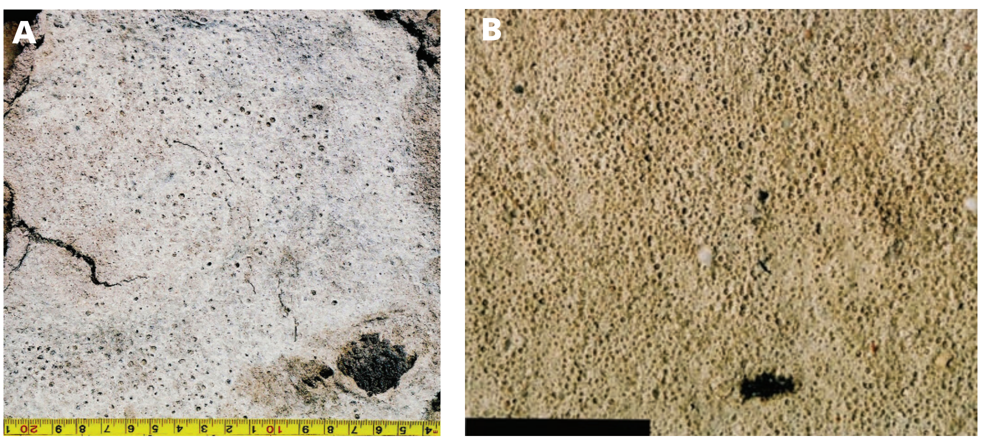

Figure 5 Sieve-like-surfaces on modern sediment. (A) Siliciclastic setting, Matagorda Peninsula, Texas. (B) Carbonate setting, Laguna Madre, Texas. The tape in (A) is in cm and the scale bar in (B) is 5 cm long.

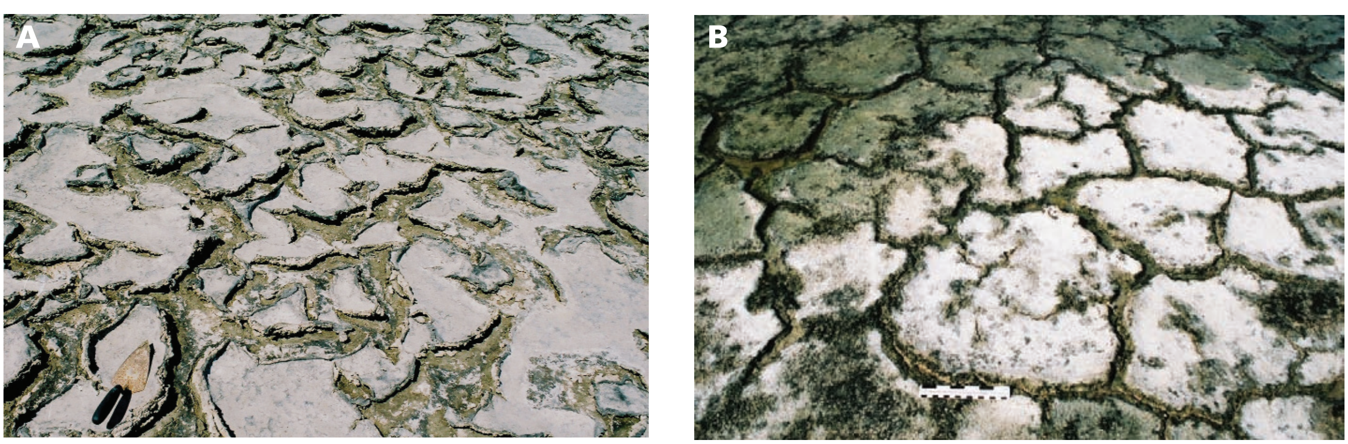

Figure 6 Sieve-like-surfaces on modern sediment. (A) Siliciclastic setting, Matagorda Peninsula, Texas. (B) Carbonate setting, Laguna Madre, Texas. The tape in (A) is in cm and the scale bar in (B) is 5 cm long.

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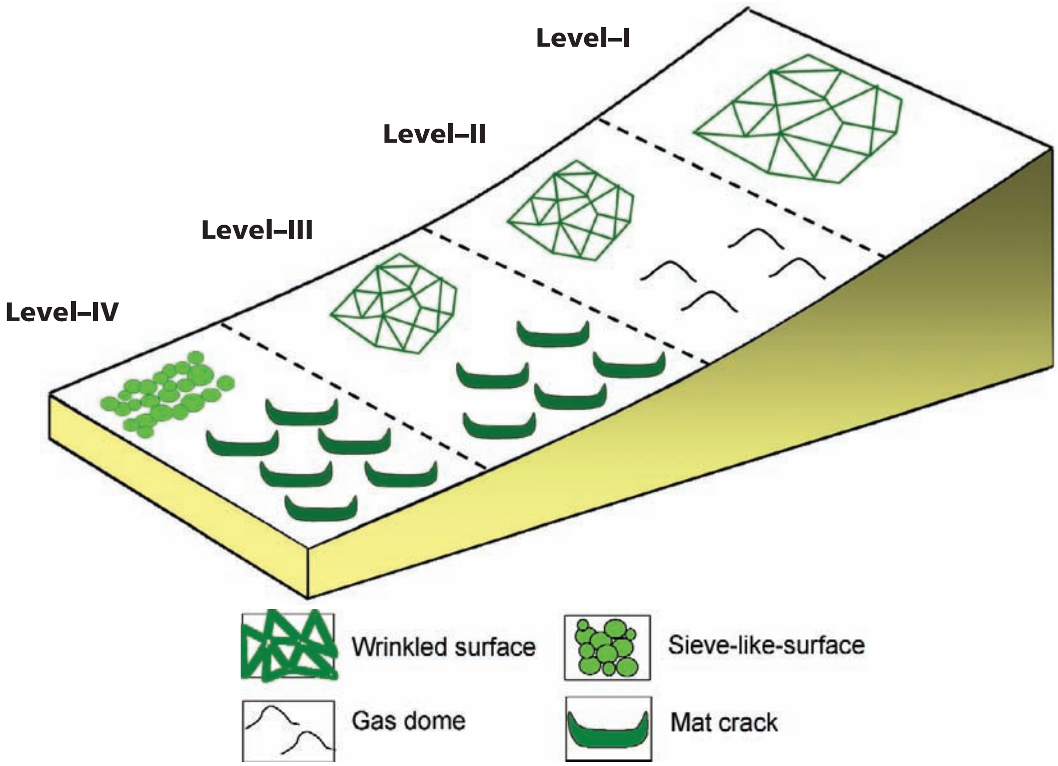

Figure 7 Relative elevations of four different assemblages of MMISS are shown here. Level-I is topographically the highest location and contains only reticulate surfaces. Level-II is marked by reticulate surfaces and gas domes. Level-III is characterized by mat-cracks and some reticulate surfaces. Sieve-like-surface and mat-cracks mark the level-IV, topographically the lowest location.