MODERN MICROBIAL FOSSILIZATION PROCESSES AS SIGNATURES FOR INTERPRETING ANCIENT TERRESTRIAL AND EXTRATERRESTRIAL MICROBIAL FORMS. Penny A. Morris[1], Susan J. Wentworth[2], Mayra Nelman[3] Monica Byrne[4], Teresa Longazo[5], Charles Galindo[5], David S. McKay, Clarence Sams[6]. [1]University of Houston Downtown, Dept Nat. Sci., 1 Main St., Houston, Tx 77002, smithp@uhd.edu; [2]NASA/Lockheed Martin, Houston, Tx., 77058; [3]Wyle Laboratories, Houston, Tx, 77058, [4]Wellesley College, Wellesley, Mass.; [5]NASA/Hernandez Engineering, Houston, Tx., 77058; [6]NASA/Johnson Space Center, Houston, Tx., 77058.

Introduction: Terrestrial biotas from microbially dominated hypersaline environments will help us understand microbial fossilization processes. Hypersaline tolerant biota from Storr's Lake, San Salvador Island (Bahamas), Mono Lake (California), and the Dead Sea (Israel) represent marine and nonmarine sites for comparative studies of potential analogs for interpreting some Mars meteorites and Mars sample return rocks [1,2,3,4,5,6].

All three sites vary in salinity, pH, water chemistry, and seasonal temperature changes. Storr's Lake is located at sea level and receives its waters from conduits within the bedrock and seepage through Holocene sand that allows limited exchange with the ocean. The waters range in temperature from 32.5 to 42^o C, pH is 8,and the average salinity is 70 g/l [7,8]. The dominant cations (in descending order) are Na, K, Ca, Mg. The Dead Sea is 400 m below sea level and receives its waters from the Jordan River system and a series of springs. Salinity is ~229.9 g/l, pH in the upper water mass is 6.3, waters are 32-35^o C, and the dominant cations (in descending order) are Mg, Na, Ca, and K. Mono Lake is in a closed desert basin at 2100 m above sea level. The pH is 9.7, temperature range is 0 to 25^o C., salinity is 70-90 g/l, depending on the time of the year. Dominant cations (in descending order) are Na, K, Ca, and Mg (our analysis at collecting sites).

The purpose of this study is to compare microbial fossilization processes, the dominant associated minerals, and potential diagenic implications.

Methods: The Storr's Lake samples were collected from .5-1 m depth and kept at ~3.0^{0}C until they were processed in the laboratory. Samples to be used for analysis with scanning electron microscopy were preserved in 10% formaldehyde on the same day they were collected. Dead Sea and Mono Lake samples were collected from ~.5 to 1.5 m depth and immediately preserved with 3% formaldehyde. Halite samples from the Dead Sea were kept moist in sterile plastic bags as they would have dissolved in formaldehyde, and dissolution would alter the relationship of the microbes to their substrates. Storr's Lake, Mono Lake, and Dead Sea materials represent benthic samples. Larger samples were fractured while smaller samples (sand-sized and smaller) were critically point dried and coated with platinum before analysis with either a JEOL 6340F field emission scanning electron microscope (FE-SEM) or Philips XL30 environmental electron microscope (ESEM). A Scintag X-ray powder difractometer (XRD) was used for Dead Sea benthic mineral identification.

Discussion: Samples from the three sites differed from each other both macroscopically and microscopically. Storr's Lake samples were collected from bulbous, crust-type stromatolite structures. Thick, slimy biofilm deposits were present. FESEM images identify the presence of biofilms, filaments, rods, ovoid, dumbbell and spherical forms, diatoms, and other microscopic forms. EDS analysis indicates that Mg is apparently associated with SiO_2. Cyanobacteria and fungal filaments are composed of Mg enriched $CaCO_3$ with varying levels of S. Dumbbells are similar but lack S. Spheres are similar to the filaments, but they contain varying amounts of both S and Si. None of the elements (Mg, Ca, Si, S) associated with the microbial fossilization process are among the two dominant cations identified from the water samples.

Macroscopically, extensive tufa and benthic mats characterize Mono Lake. FESEM and ESEM indicate the presence biofilms, rods, filaments, and diatoms. EDS analysis indicates that, the biota does not consistently contain high levels of Ca, but Si is dominant and the common element associated with the various morphologies. Mg and Al are associated with some morphologies, i.e., biofilms and filaments, but not all probable microbes. Fe is also found associated with some filaments, while some are cyanobacteria, some appear to be fungal hyphae. Internal molds of cyanobacteria are common in some samples. The molds are porous, rich in Ca, and contain varying amounts of Mg, Si, and Fe. The cyanobacteria sheath appears to easily degrade and contains significantly lower levels of Ca and Si, but Mg Al, Fe are similar to those levels associated with the internal molds. As was the case with Storrs Lake, the two dominant cations are not associated with microbial fossilization processes.

Macroscopically the Dead Sea does not appear to contain any microbial forms. Microscopically, a variety of halophilic microbes inhabit the inland lake

[9]. ESEM and FESEM images indicate the presence of thin and poorly developed biofilms, clumps of rod and spheroidal forms covered by biofilms, elongated, rod-like forms attached to the substrate by a sucker-like extension. Spheroidal forms are the only morphologies associated with mineral deposits. EDS analysis indicates the present of $CaCO_3$ and very low Mg levels. In contrast to Mono Lake and Storrs Lake, the dominant cation in the waters, Mg, is associated with microbial fossilization.

Conclusions: The three sample areas vary morphologically and chemically. Evidence of microbial activity is easily identified with the presence of Storrs Lake stromatolites and excessive biofilms, and Mono Lake tufa structures. Dead Sea microbial activity is not visually discernible. The dominant cations present in the waters, with the exception of the Dead Sea, are not consistently associated with fossilization. The primary force controlling mineralization in these systems are the microbes because of their ability to attract both actively and passively metallic ions on their surfaces, and altering the chemistry of the immediate environment through secretion of biofilms. Biofilm secretion enhances mineral precipitation [10,11]. For example, precipitation of Si in Si under saturated shallow marine waters requires biotic activity [12,13]. Si is associated with microbial fossilization at Storrs Lake and Mono Lake. The presence of S in fossilized Storrs Lake microbes may also be attributed to microbial activity [14].

Continued deposition of microbial deposits at the three sites, and the enhanced precipitation of minerals associated with microbial fossilization may ultimately affect diagenesis and mineralogical composition of the rocks [14,15,16]. Many of the elements, including Si and S, upon burial and subsequent lithification, would not be available for recycling within the original aquatic system. Their accumulation over an extended geological period of time could indicate higher levels of these elements than were actually present in the depositional environment. The interpretation of the paleoenvironment using rocks may not reflect the original depositional environment..

References: [1]Wentworth, S. J., et al. (2001) *GSA Ann. Mtg., Boston, 2001,* A403. [2]Moersch, J. E., et al (2001) *GSA Ann. Mtg., Boston, 2001*, A403. [3]Baldridge, A. M., et al (2001) *GSA Ann. Mtg. Boston, 2001,* A404. [4]Byrne, M. et al. (2001) *GSA Ann. Mtg. Boston, 2001,* A405. [5]Morris, P. A. et al (2001) *GSA Ann. Mtg., Boston, 2001,* A452. [6]Morris, P. et al. (2002) *World Space Congress, 200,, COSPAR F3.BO.6-0019-92.* [7]Neumann, A. C. et al (1988) *Proc. 4th Symp. Geol. Bahamas* 1-26. [8]Paull, C. K. et al (1992) *Paleogeogr. Paleoeclim. Paleoecol. 95* 335-344. [9]Aral, D. R. et al (1999) *Intern. J. Systematic Bacter 49,* 521-530. [10] Chafetz, H. (1994) *Biostabilization of Sediments* edits W. E. Krumbein, D. M. Paterson, L. J. Stal, Oldenburg, Germany, p.149-163. [11]Beveridge, T. J. et al (1989) *Metal Ions and Bacteria edits* T. J. Beveridge, R. J. Doyle, 450 p. [12]Mera, M. U. et al (1993) *J. Bacteriol. 175* 1936-1945. [13]Ferris, F. G. et al (1988) *Geology 16* 149-152. [14] Benison, K. C. et al (2001) *GSA Ann. Mtg Boston, Mass* p.A452. [15]Allen, C. C. et al (2001) *Astrobiology 1* 111-123. [16]Konhauser, K. O. et al (1994) *Geol. Assoc. Canada* p. 144.

Acknowledgments: NASA Astrobiology Institute grant NAG9-1113, NAG9-1114.