MICROBIALLY INDUCED PRECIPITATES: EXAMPLES FROM CO_3-, Si-, Mn- AND Fe-RICH DEPOSITS, H.S. Chafetz, Department of Geosciences, 312 S&R Bldg. #1, University of Houston, Houston, Texas 77204-5007, HChafetz@uh.edu.

Microbially induced precipitates studied from a wide range of warm to hot water spring accumulations provide insight with regard to recognition of possible extraterrestrial microbial fossils. In general, hot spring deposits exhibit a change of precipitate morphology with the evolution of the spring waters from orifice toward the downflow terminus. Nevertheless, the accumulations have a number of features in common as well as some attributes that are not universally exhibited. Among the most obvious microbial precipitates are the stromatolitic bacterial shrubs that are common in the CO_3- [1], Si- [2], Mn-, and Fe-rich [3] deposits. The shrubs, commonly up to 4 cm high, are highly irregular in morphology, that is they do not display any regular repeating pattern that would be an indication of a mineral habit. In addition to the shrub morphology, these features exhibit either bacterial fossils and/or micron-sized pores (the former sites of bacteria). The bacterial fossils and the micron-sized pores are absent in the immediately enveloping mineral deposits. Newly formed microbially induced precipitates commonly display epifluorescence, an indication of the presence of light hydrocarbon remains of the microbes. However, in some slightly older deposits only a few meters below the surface, the organic matter comprising the microbes has rapidly decayed and been completely removed by the hot, oxygen-rich waters that course through these porous strata. Consequently, the microbially induced mineral precipitates are commonly a better indicator of the former presence of the microbes than the organic molecules.

Shrub morphology was not recognized in actively forming black Mn-rich hot spring deposits from Yellowstone N.P. The most prominent gross morphology consists of Mn-rich precipitates that envelope cyanobacterial threads (fig. 1) and also form dense millimeter thick laminae fig. 2). These black precipitates formed in waters that had less than 0.2 ppm Mn, i.e., highly undersaturated. This is consistent with the fact that biotically induced oxidation of Mn (II) is up to 5 orders of magnitude faster than abiotic oxidation [4] and many taxa of bacteria have this ability to act as a catalyst. Both the coated cyanobacterial threads and the dense laminae are composed of curved sheets of amorphous Mn-rich "minerals" that have precipitated around a lattice of rod-shaped bacterial bodies, i.e., the sheets filled the curved planes between the bacterial rods (figs. 3 and 4). This is similar to the micro-architecture of Mn-rich shrubs from slightly older deposits in New Mexico and Morocco.

These deposits readily undergo diagenesis. In Yellowstone N.P., modern siliceous microbial precipitates are opal-A whereas older shrubs approximately 5m lower in the same core are opal-CT. In a somewhat analogous change, Mn- and Fe-rich precipitates in Yellowstone hot springs are amorphous whereas precipitates of similar elemental composition from older Holocene-Pleistocene deposits in New Mexico and Morocco have "matured" into pyrolusite, cryptomelane, and birnesite. Additionally, and significantly, the organic molecules can be rapidly decayed and removed, and thus, the absence of organic molecules can not be interpreted a priori as conclusive evidence of an abiotic origin. Consequently the morphology of the precipitates can be the most prominent and reliable indication of the former presence of microbial communities.

References: [1] Chafetz H.S. and Guidry S.A. (1999) Sed. Geol. 126, 57-74. [2] Guidry S.A. and Chafetz H.S. (2003) Can. J. Earth Sci. 40, 1571-1583. [3] Chafetz H.S. et al. (1998) J. Sed. Res. 68, 404-412 [4] Tebo et al. (1997) Rev. Min., #35.

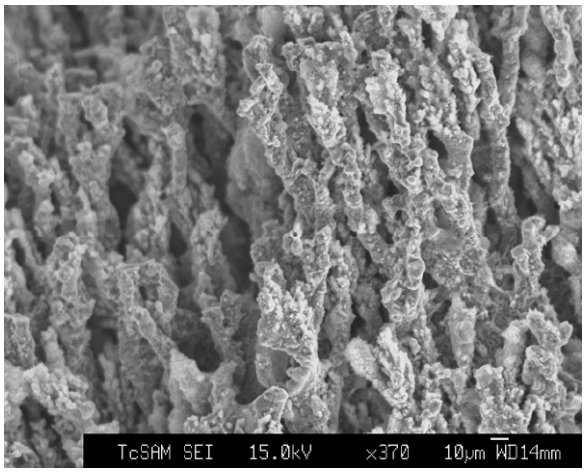

Fig. 1: Cyanobacterial threads coated by Mn-rich amorphous precipitates.

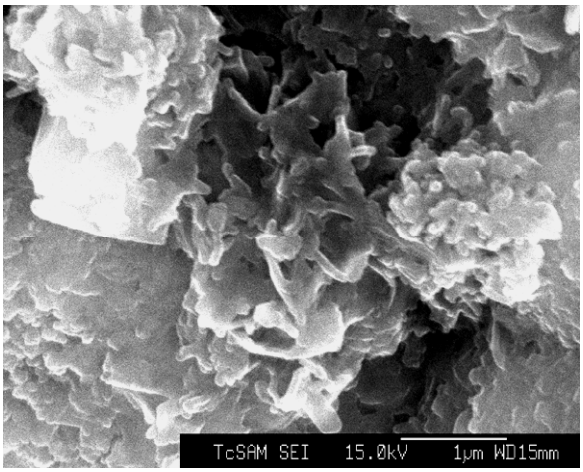

Fig. 3: Higher magnification view of cyanobacterial threads (see fig. 1) coated by curved sheets of Mn-rich precipitates that formed between an irregular "lattice-work" of bacterial body fossils.

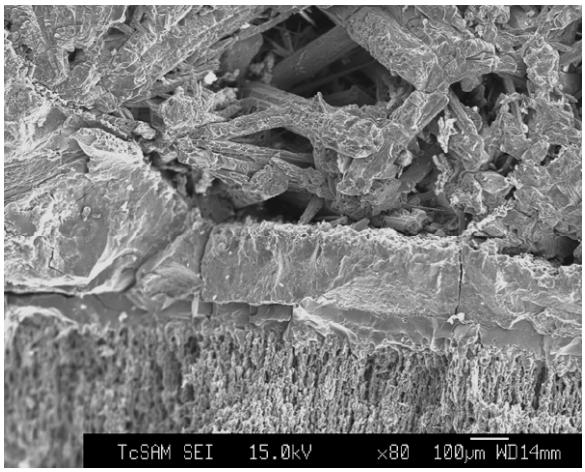

Fig. 2: In the middle, a dense laminae of Mn-rich precipitates between Mn-coated cyanobacterial threads below (similar to fig. 1) and splays of aragonite above.

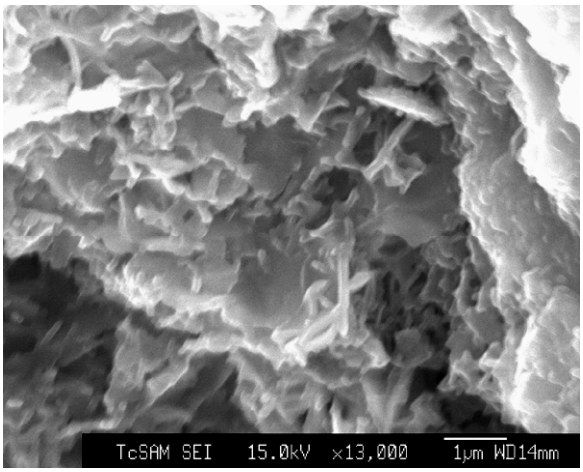

Fig. 4: Higher magnification view of dense laminae (see fig. 2) shows that it is composed of curved sheets of Mn-rich precipitates and an irregular "lattice-work" of bacterial body fossils.