TESTING ALTERNATIVE HYPOTHESES FOR THE ORIGIN OF HYDROTHERMAL SILICA AT HOME PLATE, MARS WITH IMPLICATIONS FOR ASTROBIOLOGY. S. W. Ruff, J. D. Farmer, and M. Juarez Rivera, School of Earth and Space Exploration, Arizona State University, Tempe, AZ, steve.ruff@asu.edu.

Introduction: In 2007, the Spirit rover observed rocks and soil composed of opaline silica adjacent to the volcaniclastic sedimentary deposit known as Home Plate in Gusev crater. Abundant evidence supports a hydrothermal origin for the silica, with important implications for astrobiology [1]. Hydrothermal systems produce silica both through acid leaching by fumarolic vapors and chemical sedimentary processes via hot springs and geysers. Stratigraphic, morphologic, textural, and spectral features of Home Plate silica occurrences favor the latter process, based on field analog studies and supporting laboratory investigations [2; 3]. This work also has led to the hypothesis that distinctive nodular and digitate forms of Home Plate silica could arise through a combination of biotic and abiotic processes, based on similar forms found in modern hot spring deposits on Earth [3]. This provocative scenario warrants additional scrutiny. Our ongoing investigations include new fieldwork at different hydrothermal sites, supported by various laboratory methods and analyses. These studies provide additional support for a hot spring origin and a potential role for microbes in the formation of Home Plate silica.

Fieldwork: The high elevation (~4300 m) hot spring silica deposits (sinter) of El Tatio at the edge of Chile’s Atacama Desert provide the best spectral and morphological match yet to Home Plate silica, likely due to more Mars-like conditions compared with lower and wetter hydrothermal sites on Earth [3]. We visited two other high elevation (~4100 - 4200 m) hot spring sites in the Chilean Andes ~340 km NNW of El Tatio in an effort to characterize additional silica occurrences under similar conditions. Both Puchuldiza and Tuja display nodular silica within hot spring discharge channels, some with a halite (NaCl) crust, as seen at El Tatio and also evident at Home Plate [3]. An example at Tuja is notable for having both nodular and digitate silica structures that are comparable to some at Home Plate (Fig. 1). A striking feature of the Tuja nodules is that, despite their rubbly appearance, they are firmly attached to a substrate, requiring a rock hammer and chisel to remove. This characteristic also is seen at Home Plate where Spirit’s rolling wheels failed to disturb silica nodules in several places along its traverse, including among the nodules in Fig. 1 [2; 3].

The underside of the chiseled silica nodule shown in Fig. 1 displays the organic remains of microbial biofilms. Where it was attached to the substrate, finely laminated structures are evident, including one that has a stromatolite-like form. Laboratory work is ongoing to fully characterize the features of these samples.

Figure 1. Nodular and digitate silica at Home Plate (top; Pancam subframe, sol 778) resembles hot spring sinter at Tuja, Chile at the same scale (middle; compass edge is 6 cm). Yellow arrow points to a chiseled-out sample that displays organic matter and a stromatolite-like structure on its underside (bottom, red arrow).
Laboratory Work: An alternative hypothesis for the Home Plate silica structures is that they are the result of the action of wind and sand over time. Aeolian erosion certainly is evident among the rocks around Home Plate [e.g., 4], and the silica rocks likely are no exception. We have begun experiments using a sand-blasting cabinet to qualitatively assess the effects of aeolian erosion on silica rocks. The abundant wind-abraded vesicular basalt rocks at Home Plate [4] serve as a sort of witness sample to the effects of aeolian erosion on a known rock type. Our sand-blasting test on a young Hawaiian vesicular basalt sample demonstrated that this approach can indeed simulate the appearance of wind-abraded Martian vesicular basalt.

To investigate an erosional origin for the Home Plate digitate silica structures, we started with a piece of sinter breccia, a sedimentary rock type common among hot spring deposits and a textural analog to at least one silica rock identified at Home Plate [2]. Sinter breccia can be coarsely clastic and perhaps susceptible to aeolian erosion in which harder clasts would preferentially stand out relative to softer ones. We sand-blasted a coarsely clastic sample from El Tatio to investigate this scenario, which resulted in enhanced porosity and pitting but no protruding digitate structures. Instead, it now more closely resembles a nondigitate silica rock investigated with Spirit’s Microscopic Imager (MI), especially after filling the pores and pits with basaltic sand, as is the case with the Martian rock (Fig. 2).

Conclusions: Nodular and digitate opaline silica rocks that resemble those adjacent to Home Plate are now recognized in three separate alkali-chloride hot spring systems that occur in low precipitation, high evaporation environments in Chile. The contribution of microbes to the formation of digitate silica structures was demonstrated previously for one of these sites [3] and is now being investigated for the other two. Our first sand-blasting experiment failed to produce digitate structures on a hot spring sinter breccia but adds support to the possibility that a wind-eroded form of this rock type is present at Home Plate. Many more such experiments are planned on a range of silica samples.


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Figure 2. A piece of El Tatio hot spring breccia exposed to sand-blasting (top) resulted in enhanced porosity and pits but not digitate structures. With the addition of basaltic sand, it resembles the sand-covered Home Plate silica rock dubbed Nancy Warren (bottom inset; Pancam subframe, sol 1234) shown in a portion of a MI mosaic (bottom, sol 1227, produced by R. Burnham). Both grayscale images span ~3 cm.