SEARCHING FOR LIFE ON EARLY MARS: LESSONS FROM THE PILBARA.

J.D.A. Clarke[1] and C. R. Stoker[2], [1]Mars Society Australia jon.clarke@bigpond.com, [2]NASA Ames Research Center, Moffett Field, CA 94035, carol.stoker@nasa.gov

Stromatolites in the Pilbara region of Western Australia constitute the earliest outcrop-scale evidence of life on Earth (Figure 1). The stromatolites in the 3.4 Ga Strelley Pool Formation (SPF) provide an important analog for searching for fossil evidence of early life on Mars, as Noachian aged sediments on Mars were formed under similar environmental conditions. Stromatolites represent possibly the best evidence that could be collected by a rover because they form recognizable macroscopic structures and are often associated with chemical and microscopic evidence.

Figure 1: 3.4 Ga stromalites of the Strelley Pool Formation.

Analog Site Work: Field and basic laboratory investigations of SPF stromatolites near Nullagene Australia (Clarke and Stoker, 2013) helps illustrate issues important for searching for past evidence of life on Mars. We mapped 38 different stromatolite locations within 18 outcrops or clusters of outcrops. Morphologies were domes (45 imaged) low relief domes (26 imaged) and cones (25 imaged). There was abundant evidence for hydrothermal activity including hydrothermal breccias, cavity filling quartz, and nail hole columns of bladed barite, consistent with the suggestion that stromatolite grew in areas of hydrothermal activity (Van Kranendonk 2006). Because of the sensitive nature of the site, no rock hammering was performed to acquire samples but some small float samples were obtained. Field spectra were acquired using an Integrated Spectronics SWIR (1300-2500 nm) PIMA field portable spectrometer. Typical minerals identified in stromatolitic lithologies were dolomite, calcite, talc, and hornblende. Primary phyllosilicates were talc and phengite (Table 1).

One outcrop selected for laboratory study consisted of partially silicified limestone with undulating laminations. This sample was examined in thin section via petrographic microscope. The stromatilites were originally calcite, variably replaced by dolomite and silica. No evidence of cellular structure or microfossils was found in the thin sections, nor would be expected given the crystallized nature of the carbonates and the late silicification. However the stromatolites appear strongly biogenic in form. SWIR spectra were obtained with the PIMA (Table 1) and XRD data with a Terra X-Ray diffractometer (Sarrazin et al., 2008), a commercial version of the CHEMIN on MSL (Table 2). Mineralogy within the sample consists of quartz, calcite and talc.

Discussion: Findings from the analog site provide some lessons for Mars sample return to search for evidence of life. Stromatolites are rare, possibly outcropping in only one millionth of the area of the Pilbara. Even where the stromatolites are found, they make up ~1% of the host unit and considerable traversing to look at every outcrop is needed to study the area and select the best samples. The stromatolite morphology in our field sample is the only evidence of biogenic activity, organic carbon or microfossils are not preserved. The stromatolitic outcrops in the Pilbarra are steeply dipping whereas on Mars they are likely to be flat lying so exposures may only be on steep walls of craters or valleys, making them difficult to access. Brown et al. (2005) showed that high resolution (5 m or better) hyperspectral imagery was needed to identify alteration zones where stromatolites are found; CRISM resolution at 15m/pixel was unable to allow this mapping. Even if the right outcrops are found and sampled, considering that it has taken many decades of careful work by teams of researchers studying hundreds of kg of samples to prove the likely biogenicity of the Archean Pilbara stromatolites, proof of early life on Mars with sample return is unlikely.

Table 1: PIMA hyperspectral analyses (those marked * also analysed with XRD)

Sample location	Lithology	Minerals
Interior	Marble	Calcite
Exterior	Silicified limestone	Talc, hornblende, dolomite
Interior	Silicified limestone	Talc, hornblende
Interior	Silicified limestone	Talc, hornblende, dolomite
Exterior *	Silicified limestone	Talc, tremolite, dolomite
Interior*	Silicified limestone	Talc, hornblende, dolomite
Interior*	Silicified limestone	Talc, hornblende, dolomite

Table 2: Terra XRD analyses

Sample location	Lithology	Minerals	%
Exterior	Silicified limestone	Quartz Calcite Talc	61.7 8.9 29.4
Interior	Silicified limestone	Calcite Talc Dolomite Quartz	53.7 25.0 15.2 6.2
Interior	Silicified limestone	Quartz	100

References:

Clarke, J.D.A. and Stoker, C.R. (2013) Icarus 224, 413-423.
Van Kranendonk, M.F. (2006) Earth Sci. Rev.74, 197-240.
Sarrazin, P. et al. (2008) LPSC 36, abstract 2421.
Brown, A.J. et al. (2005) Aus. J. Earth. Sci. 52 (3), 353-364.