A HYPERSALINE SPRING ANALOGUE IN MANITOBA, CANADA FOR POTENTIAL ANCIENT SPRING DEPOSITS ON MARS. G. Berard[1], D. Applin[1], E. Cloutis[1], J. Stromberg[2], R. Sharma[1], P. Mann[1], S. Grasby[3], R. Bezys[4], B. Horgan[5], K. Londry[6], M. Rice[7], B. Last[8], F. Last[8], P. Badiou[9], G. Goldsborough[10], J. Bell III[5]. [1]Dept. of Geography, U. of Winnipeg, MB, Canada, [2]Depts. Earth Sciences/Physics and Astronomy, U. of Western Ontario, ON, Canada, [3]Geological Survey of Canada, Natural Resources Canada, AB, Canada, [4]Wildwood Geological Services, MB, Canada, [5]School of Earth and Space Exploration, Arizona State U., Tempe, AZ, USA, [6]Dept. Biological Sciences, U. of Alberta, AB, Canada, [7]Dept. of Astronomy, Cornell U., NY, USA, [8]Dept. Geological Sciences, U. of Manitoba, MB, Canada, [9]Institute for Wetlands and Waterfowl Research, MB, Canada, [10]Dept. of Biological Sciences, U. of Manitoba, MB, Canada.

Introduction: This study explores the characteristics of a spring complex, East German Creek, Manitoba (EGC), as a terrestrial analogue for similar environments on Mars. Here we focus on EGC's mineral precipitation patterns and potential for biosignature preservation to gain insights into how past processes may have operated in similar environments on Mars. This study was initiated because of the tentative identification of potential ancient spring deposits in Vernal Crater, Arabia Terra [1], as well as in the intercrater plains of Terra Sirenum [2]. The importance of such deposits is that, depending on formation conditions, such a spring environment may have acted as a "last refuge of life" on Mars by providing mineral-rich liquid water as the planet cooled and dried [3]. An assessment of mineral precipitation patterns, water chemistry, and subsurface-derived methane fluxes was conducted at EGC. Reflectance spectroscopy and XRD analysis of sediments in the outflow stream and outwash plain were also conducted to determine the spectral detectability of any biosignatures, and what mineral precipitates might overlay them. As well, changes in surface precipitates and stream sediments with distance from the main springs were examined.

Fig. 1: "Big Cauldron", the largest spring at the EGC site, Oct. 2010. The central pit is ~2 meters wide. Photo: G.Berard

Experimental Procedure: Methane samples from outlets were collected in 2006 with customized gas collection vessels and were analyzed by gas chromatography. Water and stream sediment samples were collected from the EGC site in May 2010. The main spring, "Big Cauldron" (Fig.1), and 10 additional sample stations along the outflow channel were sampled. Outwash plain sediment samples were collected based on tonal and texture variations in Sept. 2011, then dried under Mars-like conditions. Molecular and ionic concentrations in the water (NaCl, N, Mn, Mg, SO_3, $CaCO_3$, SiO_2, Fe) were determined using a Palintest 7500 photometer. Temperature, salinity, and pH were also measured in the field. The water from each sample station was evaporated in air to precipitate dissolved species. Precipitates (ground to <1000 µm), stream sediments, and outwash plain sediments were analyzed with an ASD Fieldspec Pro HR spectrometer (300-2500 nm) and by XRD.

Results-Water Chemistry: Water temperature, pH, dissolved N, NaCl, and $CaCO_3$ all diminish with distance from Big Cauldron. Dissolved Mg decreases initially and then levels out after station 6. Salinity drops off between stations 4 and 6. SO_4 and Fe concentrations decrease after station 4.

Results-Precipitates: Halite was the dominant mineral precipitate as determined by XRD; however, halite does not have a spectral signature within the 350-2500 nm region. Therefore, gypsum was the most spectrally dominant precipitate. Halite precipitation is fairly consistent along the length of the stream, and most gypsum is precipitated at the first few stations.

Results-Stream Sediments: There are three main results from stream sediment analysis: **1.** XRD shows that the main mineral present was calcite. Calcite becomes more spectrally prominent with distance from the main spring (Figs. 2, 3); **2.** Fe^{3+} is present as a surficial coating but is volumetrically minimal, as evidenced by its strong spectral signature below ~900 nm and absence in XRD. **3.** A 670 nm absorption feature, due to chlorophyll, is present in all samples.

Results-Outwash Plain Sediments: There are five main results from our outwash plain sediment analysis: **1.** Carbonate and gypsum absorption features become more evident after drying under

Mars-like conditions (Fig. 4). **2.** Cyanobacterial mat formation and gypsum precipitation are intimately related. **3.** The 670 nm chlorophyll feature persists after drying under Mars-like conditions (Fig. 5). **4.** The Fe^{3+} surficial coating is volumetrically minimal (Fig. 6) **5.** The ~2300 nm carbonate absorption feature is identifiable through the Fe^{3+} surficial coating, but weak because of abundant (surficial) gypsum and/or halite.

Results-Biological Investigation: Chambers that were placed in areas covered by *Percursaria percursa* mats had methane fluxes similar to those observed in the spring pool and channel sites with little algal cover. Chambers placed over open-water areas surrounded by algal mats had higher methane gas fluxes: from 29.1 to 95.4 CH_4-C $mg.m^{-2}.d^{-1}$.

Implications for Mars: The results of this study show: **1.** Carbonate deposits on Mars should be detectable using CRISM or other spectrometers if they are coated in a layer of ferric minerals because of the persistence of a 2300 nm carbonate absorption feature. **2.** Variations in mineralogy across a spring site can be used to infer groundwater chemistry, flow patterns, and possibly surface runoff. **3.** The formation and retention of gypsum, as well as the presence of Fe-oxyhydroxides seem linked to the biological conditions at the site. **4.** A biosignature at 670 nm, indicative of chlorophyll, can be detected after the biota are completely desiccated. **5.** Methane plumes on Mars could results from spring methanogenesis.

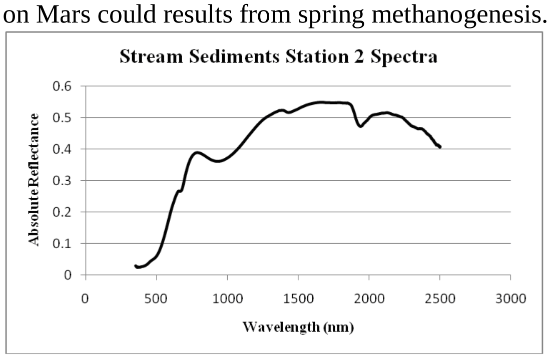

Figure 2: Spectra of stream sediments from station 2, showing the ~2300 nm calcite absorption band.

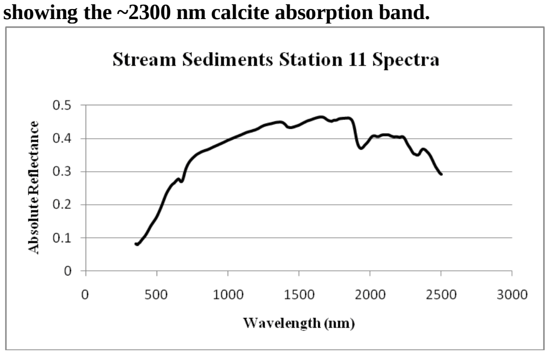

Figure 3: Spectra of stream sediments from station 11, showing strong calcite absorption band.

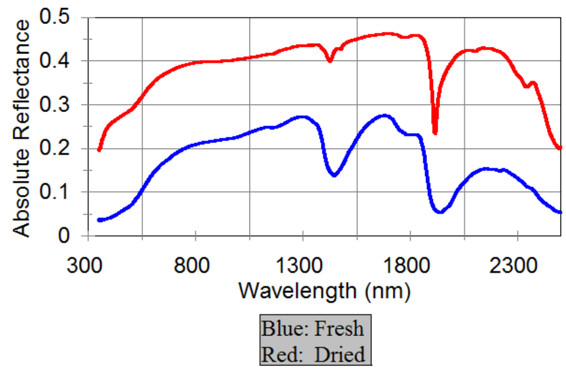

Figure 4: Spectra of brick 5 before and after drying under Mars-like conditions.

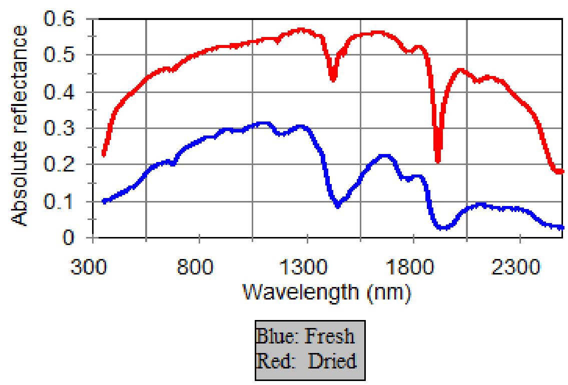

Figure 5: Spectra of brick 3 before and after drying under Mars-like conditions.

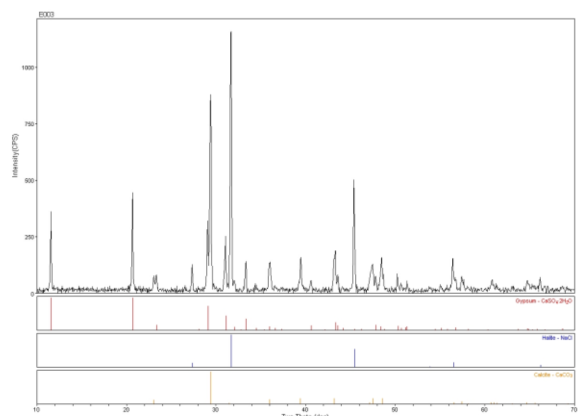

Figure 6: XRD results for brick 3.

References: [1] Oehler D.Z., and Allen C.C. (2008) *LPSC, 39*, #1949. [2] Wray J. J et al. (2011) *J. Geophys. Res. 116*, E01001. [3] Grasby S., and Londry K. (2007) *Astrobiology, 7*, 662-683.

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