

A HYPERSALINE SPRING ANALOGUE IN CENTRAL MANITOBA FOR ARABIA TERRA'S POTENTIAL ANCIENT SPRING DEPOSITS. G.M. Berard¹, E.A. Cloutis¹, J.M. Stromberg¹, P.Mann¹, B. Horgan², and M. Rice³. ¹Department of Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba, Canada R3B 2E9, ²School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA 85287-1404, ³Department of Astronomy, Cornell University, Ithaca, NY, USA 14853-6801.

Introduction: Two elliptical features have been identified from HiRISE images in southern Vernal Crater in Arabia Terra on Mars (6°N, 355.5°E) that are consistent with spring deposits. These features have terrace-like morphology, light-toned albedo, and central depressions, analogous to spring features on Earth [1]. Hyperthermal and hypersaline springs on Earth host some of the most primitive organisms, namely from the domain Archaea. If life did evolve on Mars, it could have done so in similar environments and life could have survived in these places for some time [2].

We identified the East German Creek (EGC) site (52.75°N, 100.88°W), located in western Manitoba, as an analogue site for the features in Vernal Crater [1] (Fig. 1). It consists of hypersaline, cold-water springs with high concentrations of NaCl and ammonia, creating a unique environment for microbial life [2,3,4].

Geologically, this site is dominated by low-Mg calcite (as both bedrock and precipitates), with minor quartz, feldspars, dolomite, and coatings of goethite on surfaces [3]. Some springs at this analogue site are covered in a dense mat of marine green algae, *Percur-saria percursa*, as well as cyanobacteria [2].

This investigation focuses on the changes in water chemistry, geology and mineral evaporites, and biota along the outflow channel as a function of distance from the main spring complex, and detection of carbonate bedrock through surficial precipitates [5,6].

Experimental Procedure: Water, sediment/rock, and biotic samples were collected from the EGC site in May 2010 for analysis. The main spring, "Big Cauldron", and 10 additional sample stations along the outflow channel were sampled. Molecular and ionic concentrations in the water (NaCl, N, Mn, Mg, SO₃, CaCO₃, SiO₂, 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. Reflectance spectra of the evaporites (ground to <1000 μm), fine-grained sediments, and rock samples along the outflow channel were measured with an ASD spectrometer (0.35-2.5 μm), using a 50 watt QTH light source, with i=30°, e=0°. One thousand spectra were taken and averaged to improve SNR.

Results-water chemistry: NaCl concentrations were highest at sample station 2, generally decreasing

with increasing distance from the main spring complex. N (ammonia) concentrations were highest at Big Cauldron (station 1), fluctuated between stations 2 and 4, and then decreased drastically at station 6 to a concentration below 1 mg/L at all stations further from the main spring complex. Mn concentrations were highest at Big Cauldron (0.1 mg/L), and decreased drastically from station 2 onward to values well below 0.01 mg/L. Mg concentrations increased to their highest (450 mg/L) at stations 2 and 3, and then steadily decreased to around 50 mg/L from station 7 onward. Stations 1-4 saw the highest concentrations of sulfates (~170 mg/L), with concentrations between 20-100 mg/L beyond station 6. CaCO₃ concentrations were highest at Big Cauldron (~2 g/L), decreased drastically at stations 2 and 3 (~0.4 g/L) and then increased again at station 4 (~1.7 g/L), decreased at station 6 and remained at values close to 0.12 g/L beyond this. SiO₂ fluctuated from Big Cauldron to station 12 at concentrations between 6.2-10.5 mg/L. Fe was highest at Big Cauldron (2.9 mg/L), decreasing to values >1 mg/L, except for a peak at station 4 (1.94 mg/L).

Results- evaporites: In general, gypsum appeared to be the main mineral precipitating in all 11 water samples. Halite also may have been present, but this mineral has no spectral signature in the 0.35-2.5 μm region. At stations 1-4 (closest to the main spring), gypsum features dominate the spectra.

The gypsum absorption features in the precipitate spectra for stations 6-9 are shallower than those for stations 1-4, but the overall shape of gypsum is still present. In the visible range, lower reflectance is seen between 0.3 μm and 0.7 μm in comparison to stations 1-4. The general shape of the gypsum spectrum is also observed in stations 10-12, but the evaporites from these sites may be less crystalline or overprinted by spectral contributions from other phases: the characteristic gypsum absorption features are present but wider than in pure well-crystallized gypsum. Large, single cubic crystals developed in the precipitates from stations 1 and 2 and their spectra were also characteristic of gypsum, although with less well-defined absorption features than were present in the <1000 μm grain size bulk evaporites for these stations.

Results-sediments: In general, fine-grained sediments from the sample stations were characterized by three trends (Figs.2-4). There is an absorption feature

at 2.33 μm that could indicate clay or carbonates, whose depth increases with increasing distance from the main springs. An absorption feature at 0.9 μm , decrease in reflectance in the visible range and a reflectance shoulder at 0.5 μm indicate the presence of Fe^{3+} . These features decrease with increasing distance from the main springs. An absorption feature at 0.67 μm is present in all air-dried sediment spectra, which is characteristic of chlorophyll.

Discussion: Gypsum is being precipitated at all 11 stations, although this appears to be happening to a greater degree at stations closer to the main spring complex and occurs to a lesser degree with greater distance because of decreasing availability of Ca and SO_3 .

The decrease in reflectance in the visible region from station 6 onward is likely due to increased humic acid and not Fe because Fe content in the water is very low from station 6 onward. Halite is probably also being precipitated at stations closer to the main springs as NaCl in the water generally decreased after station 2.

All ions/molecules decrease in concentration with greater distance from Big Cauldron, indicating that the main spring complex is their main source.

Fe^{3+} precipitates at the earlier stations as goethite coatings on carbonates. With increasing distance from the springs, there is less precipitation of goethite and a greater spectral signature of carbonates and chlorophyll (from cyanobacteria and algae) in the sediments.

References: [1] Oehler, D.Z., and C.C. Allen (2008) *LPSC 39*, Abstract # 1949. [2] Grasby, S. and Londry, K. (2007) *Astrobiology*, 7, 662-683. [3] Cloutis, E.A. et al. (2007) Report to CSA CARN program. [4] Grasby, S., et al (2005) *GSA Bull.*, 117, 500-514. [5] Ehlmann, B.L. et al. (2009) *Science*, 322, 1828-1832. [6] Morris, R.V. et al. (2010) *Science*, 329, 421-424.

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Fig.1 (above). EGC site (~400 metres across).

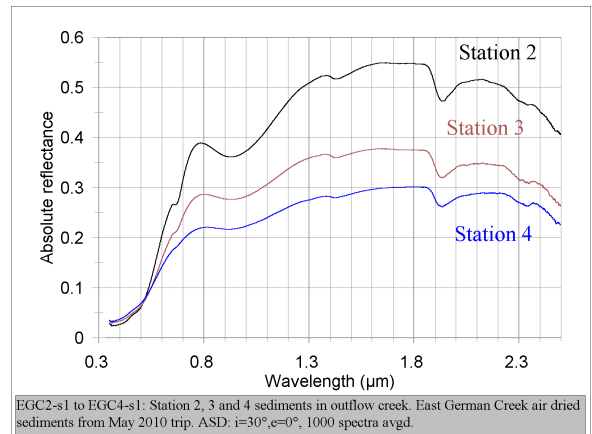


Fig.2. ASD (0.35-2.5 μm) reflectance spectra of air-dried sediments from stations 2-4.

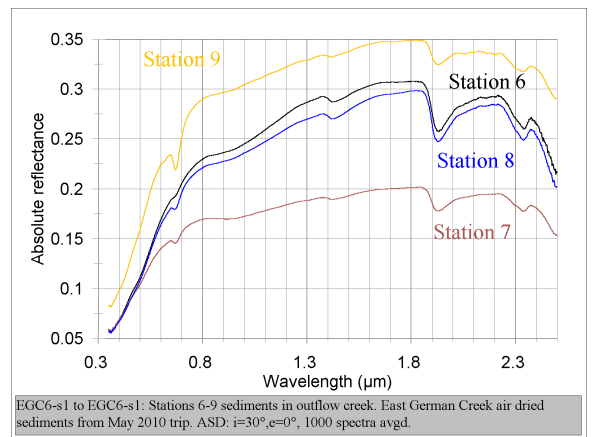


Fig.3. ASD (0.35-2.5 μm) reflectance spectra of air-dried sediments from stations 6-9.

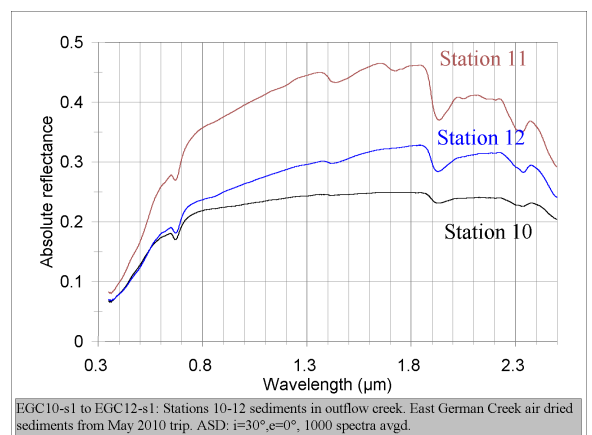


Fig.4. ASD (0.35-2.5 μm) reflectance spectra of air-dried sediments from stations 10-12.