A HYDROLOGIC- AND BIOSIGNATURE-DRIVEN FIELD CAMPAIGN AT AN INVERTED FLUVIAL CHANNEL SITE: HANKSVILLE, UT, USA.

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Introduction: The area around Hanksville, UT, USA has been extensively used as a Mars analogue site for activities such as rover field trials [1]. Most recently (November, 2016), the Canadian Space Agency, in conjunction with the University of Western Ontario conducted rover field trials at this location [2]. As a complementary activity to this deployment, we conducted a field campaign to better understand the biosignature preservation potential of the site, focusing on the capping sandstones that represent braided fluvial channels and the immediately underlying fluvial fine-grained sediments.

Our major objectives are to determine the kinds of information that can be derived in such environments using current and planned rover-mounted instruments, such as reflectance and Raman spectroscopy, and XRD/XRF in the context of biosignature detection, and to assess and compare the biosignature preservation potential of these fluvial and lacustrine materials.

Site Decription: The field site is located near the town of Hanksville, UT, USA (Fig. 1). Our research focused on the segmented and inverted anastamosing paleochannels exhumed from the the Late Jurassic Brushy Basin Member of the Morrison Formation. The paleochannels closely resemble similar features seen on the surface of Mars [3] and which may be targeted by future surface missions such as ExoMars 2020.

Figure 1. Location of the 2016 field campaign (from [4]. The channel segment marked by the arrow and two channels segments north of this location were sampled during the field campaign.

Study Goals: We used the biosignature "hot spot" criteria of [5] to target our field campaign and sampling locations. We applied these criteria in the context of the expected properties of exhumed inverted channels. The feasibility of the criteria were modified, as required, during the field campaign. The criteria used to direct the field sampling campaign included:

- sample on the basal sandstones and immediately underlying lacustrine unit, including embedded sandstone lenses;
- sample over as wide an area as possible. One of the original criteria was to determine whether biosignature hot spots are concentrated at geological boundaries. However, erosion has essentially removed this contextual information;
- determine whether biosignatures vary at the scale of centimeters to kilometers;
- sample along a fluvial-lacustrine contact zone with vertical elevation variations on the order of tens of cm over distances of a few meters;
- sample along a transect from exhumed to unexhumed fluvial sandstone
- sample around fluvial sandstone that drape over and around now eroded away cobbles.

Methodology: Samples were acquired in the field for subsequent laboratory analysis. Whenever possible we removed any weathered surfaces prior to sampling. We also focused on vertical faces and overhangs to minimize inclusion of weathered materials. Samples were placed in sterilized plastic bags and transported to the U. of Winnipeg immediately after the field campaign. A total of three channel segments were sampled, two located within 200 meters of each other ("basecamps 1 and 2"), and a third located ~5 km from the first two ("basecamp 3"). We sampled materials at the contact between the fluvial and lacustrine units, acquiring samples no further than 5-10 cm from a contact, which were uniformly sharp. To date, a subset of the samples have been analyzed by reflectance and Raman spectroscopy, and XRD.

Initial Results: The fluvial sedimentary rocks show visually apparent differences between the sampling sites in terms of grain size range, color and induration. The basal sandstones were generally friable enough to allow for easy removal. The lacustrine sediments exhibit variations in color and induration. Fluvial sandstone samples acquired away from the contact, closer to or at the surface of the exhumed channels were generally highly indurated: these samples were removed by grainding with a hardened steel chisel. The sandstones at a number of the sites exhibited greater friability and more iron staining than at other locations, likely due to post-lithification groundwater flow along the contact.

XRD results: X-ray diffractograms were acquired with a Terra instrument. Phases identified by XRD are provided in Table 1. While quantitative analysis is ongoing, quartz and a montmorillonite-like phyllosilicate were readily identifiable in all of the sample diffractograms. The presence of quartz in the lacustrine sediments was somewhat unexpected as they are composed predominantly of silt-clay sized particles. The diffractograms all show enhanced low-angle scattering and an amorphous "hump" in the 20-30° 2-theta region.

Table 1. Phases identified by XRD

Sample	*Phases identified*
BC2-C1A (lacustrine)	qtz, mon, cal, sep
BC2-C1B (fluvial)	qtz, mon,ber
BC2-C5EA (lacustrine)	qtz, mon, cal, dol.
BC2-C5EB (fluvial)	qtz, mon, cal, dol.

Abbreviations: ber: bernalite; cal: calcite; dol: dolomite; mon: montmorillonite; qtz: quartz; sep: sepiolite.

Raman results: 532 nm Raman spectra of 2 fluvial and 2 lacustrine samples are shown in Fig. 2.

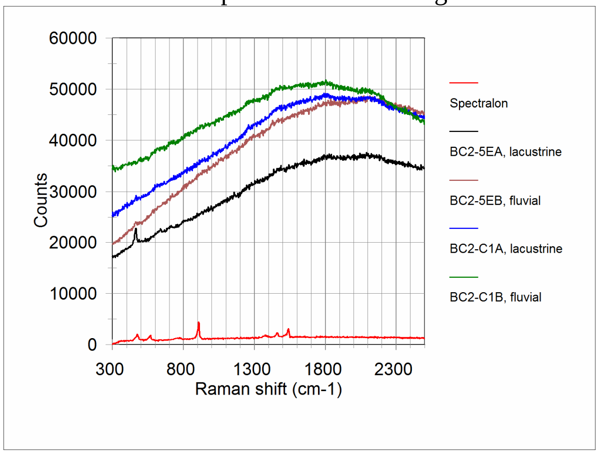

Fig. 2. 532 nm Raman spectra of 4 samples: red and purple: lacustrine samples; green and blue: fluvial samples.

Raman spectra of the unprocessed samples are all characterized by a strong fluorescence peak. Only one of the samples (lacustrine) shows a quartz peak near 490 cm^{-1}. The other phases identified by XRD (above) are not detectable in the Raman spectra. We speculate that the fluorescence hump is likely due to the presence of small amounts of Fe which give some of the samples a beige-pale red color.

Reflectance spectroscopy results: Reflectance spectra of a lacustrine-fluvial sample pair (Fig. 3) are generally similar. The presence of montmorillonite is suggested by the absorption features near 1420, 1900, and 2200 nm. The presence of quartz and carbonates is not evident from the spectra. An Fe^{2+}-bearing and mixed valence Fe-bearing phase (likely the "montomorillonite" identified by XRD) is suggested by absorption features near 900 and 1150 nm and an absorption feature near 700 nm, respectively.

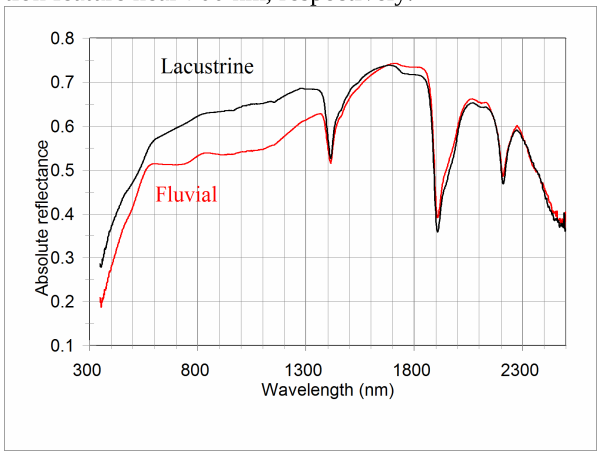

Fig. 3. Reflectance spectra of a fluvial-lacustrine pair.

Summary: The results to date demonstrate that XRD and reflectance spectroscopy are very complementary in this type of environment. As expected XRD can detect a range of crystalline materials, while reflectance spectroscopy is well suited to detecting Fe-bearing materials and constraining phyllosilicate type. The inability of Raman to detect phases other than quartz was unexpected.

Future work: The full sample suite will be analyzed using a wider range of Mars rover-relevant techniques. Samples will also be exposed to Mars surface conditions for a few months and reanalyzed with the full suite of instrument to determine their stabilities and implications for ground-based Mars exploration.

References: [1] Foing B.H. et al. (2011) *Intl. J. Astrobiol., 10*, 141-160. [2] Osinski G.R. et al. (2016) *LPSC 47*, Abstract #2616. [3] Balme M. et al. (2015) *LPSC, 45*, Abstract #1321. [4] Clarke J.D.A. and Stoker C.R. (2011) *Intl. J. Astrobiol., 10*, 161-175. [5] McClain M.E. et al. (2003) *Ecosystems, 6*, 301-312.

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