LASER-INDUCED BREAKDOWN SPECTROSCOPY (LIBS) ANALYSIS OF ORGANIC-BEARING MARS ANALOGUE SAMPLES

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Introduction:

Building on the success of the ChemCam instrument on the Mars Science Laboratory (MSL) rover, the NASA Mars2020 rover will host a refinement of the instrument, known as SuperCam. SuperCam will host four remote sensing techniques [1] that can help explore and characterize an astrobiologically relevant ancient environment and search for signs of extant or extinct life [2]. SuperCam will utilize a laser-induced breakdown spectrometer (LIBS), an updated Raman spectrometer, time-resolved fluorescence, as well as a vis-NIR reflectance spectrometer [3]. These remote sensing techniques will work together to investigate the geological, mineralogical and elemental composition of Mars.[3]

An investigation of the capabilities that a 1064 nm Nd:YAG LIBS[1] has on detecting organics in a laboratory environment was performed. The analysis was done on a suite of organic-bearing Mars analogue samples with a combined LIBS and DUV Raman instrument (LiRS), developed by MPB Communications Inc. [4]. The focus of this study is to understand LIBS ability to detect organic elements in a suite of Mars analogue samples. Preliminary findings are reported in this paper.

Samples:

The suite of samples analyzed in this study was a mix of solid rocks, and powders compressed into pellets, from a variety of Mars analogue sites. Thirty-nine samples were analyzed ranging from full rock samples comprising biofilms, endoliths, stromatolites, oil sands, and various organic-bearing geological materials and laboratory-created organic-bearing mixtures. The use of pellets for the powdered samples was necessitated by the need to mount samples vertically for the LIBS measurements.

Experimental/Results:

The instrument used for this study was a modular breadboard of integrated LIBS and DUV Raman spectroscopy techniques, (LiRS) [5]. The LIBS integration utilized a 16mJ pulse miniature 1064nm Nd:YAG laser. The integration time for analysis was 200ms. Samples were individually positioned to obtain the greatest intensity of peaks. Optimum sample placement was guided by using the acoustic signal of the LIBS-induced sample ablation. Pulse durations were 265µs, with laser pulse frequency set to 10Hz. A suite of detectors covered the wavelength range from 240nm to 830nm, with a spectral resolution of 0.08 nm FWHM at 250nm to 0.3nm near 830nm [4].

Analysis of samples was performed in ambient terrestrial conditions of atmospheric pressure and temperature. The points of interest on each sample were determined through visual identification of features that indicated the presence of organics on the surface of each sample. For example, sample ANT-EN5 showed melanized fungi striations just below the surface of the rock. In cases where visual evidence of organics was not detected, random points on sample surfaces were measured.

Preliminary Findings:

- **Detection of atomic emission peak of C (I) at 723.5 nm**
- **Detection of molecular CN emission peaks in the violet system**
- **Detection of molecular C2 Swan emission peaks.**
- **Detection of atomic N (II) peaks at 500.5 nm in synthetic samples.**

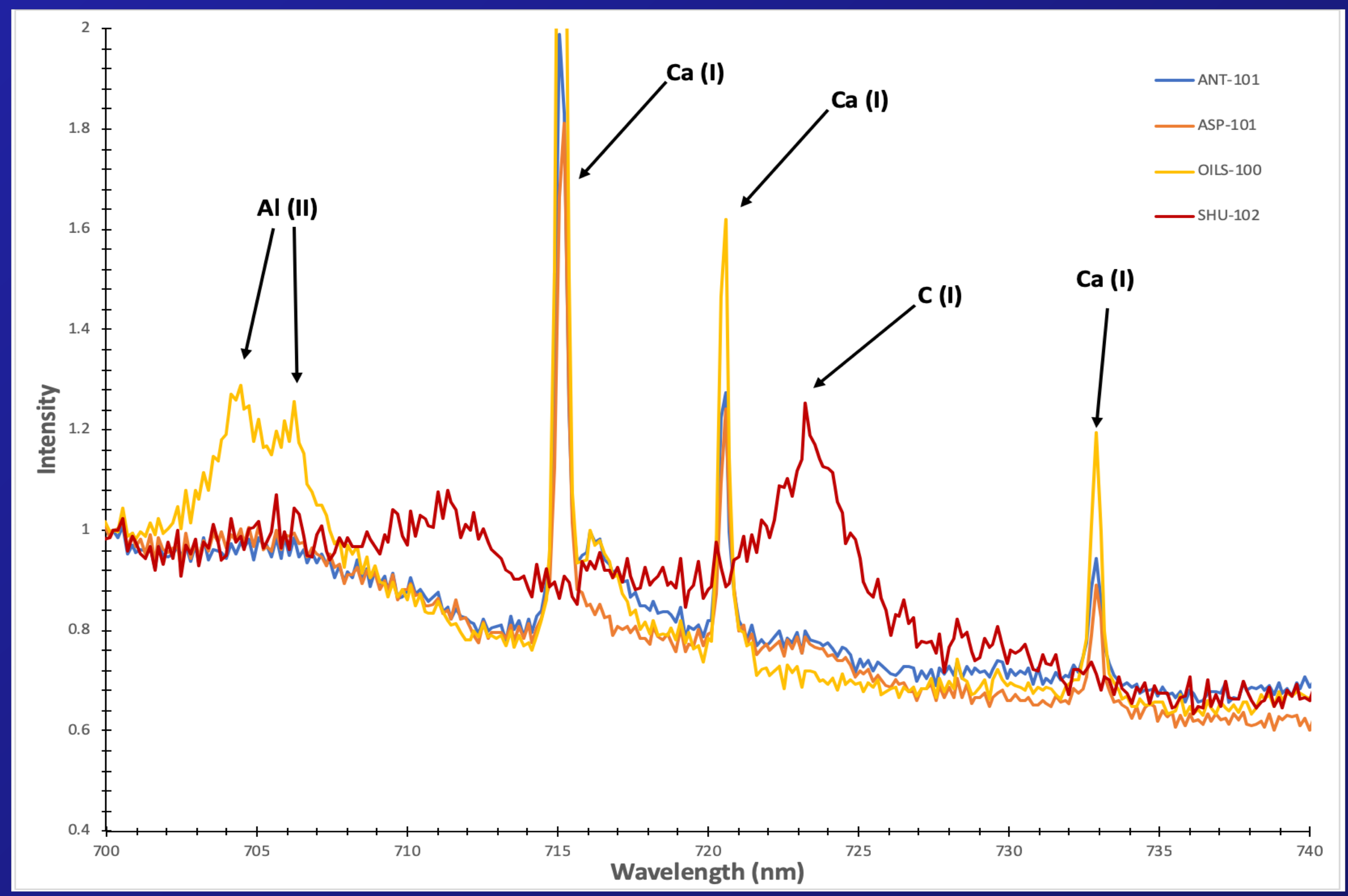

Figure 1: LIBS spectra of the atomic C (I) emission peak at 723.5 nm.

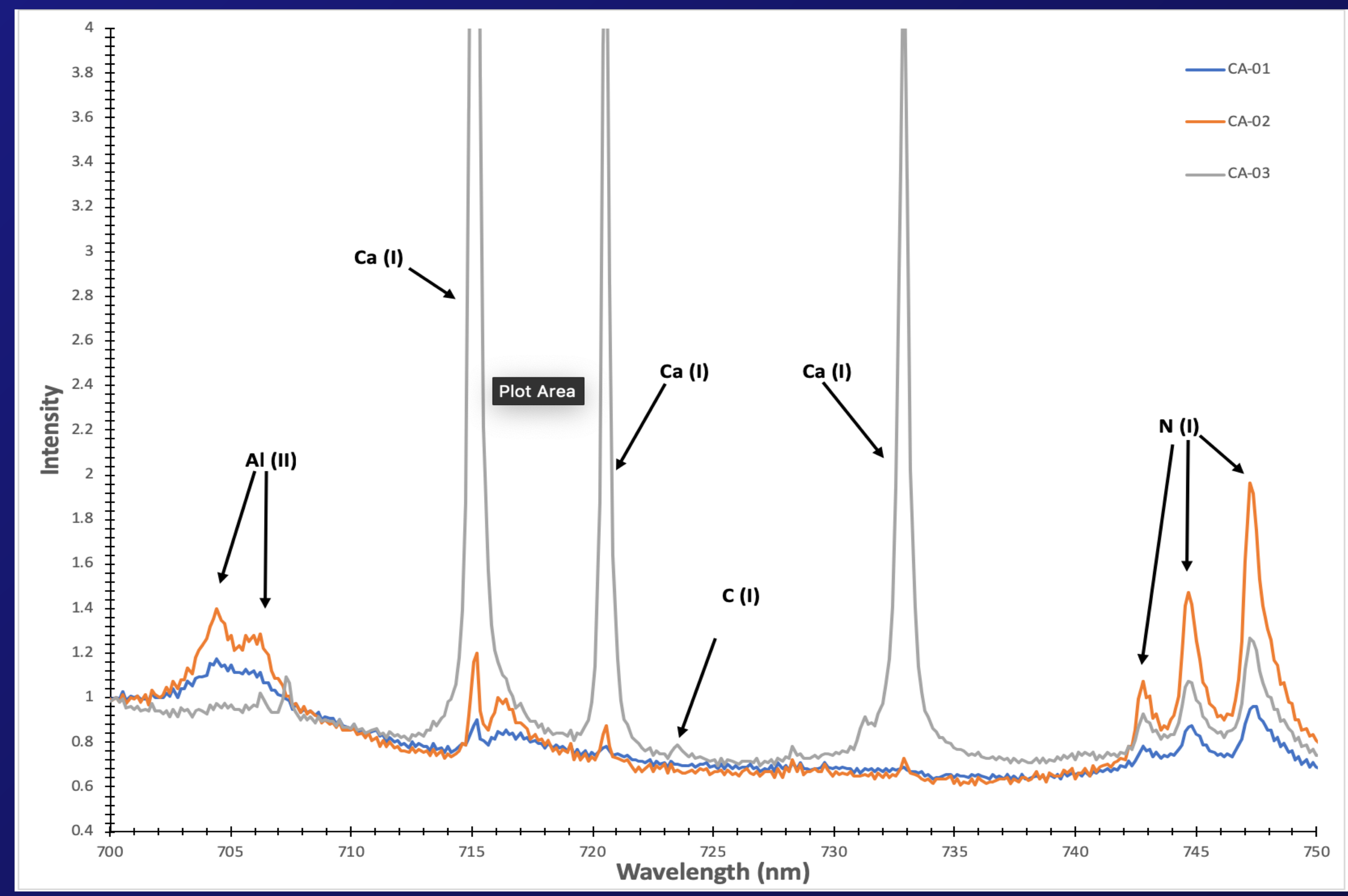

Figure 2: LIBS spectra of the atomic C (I) emission peak at 723.5 nm.

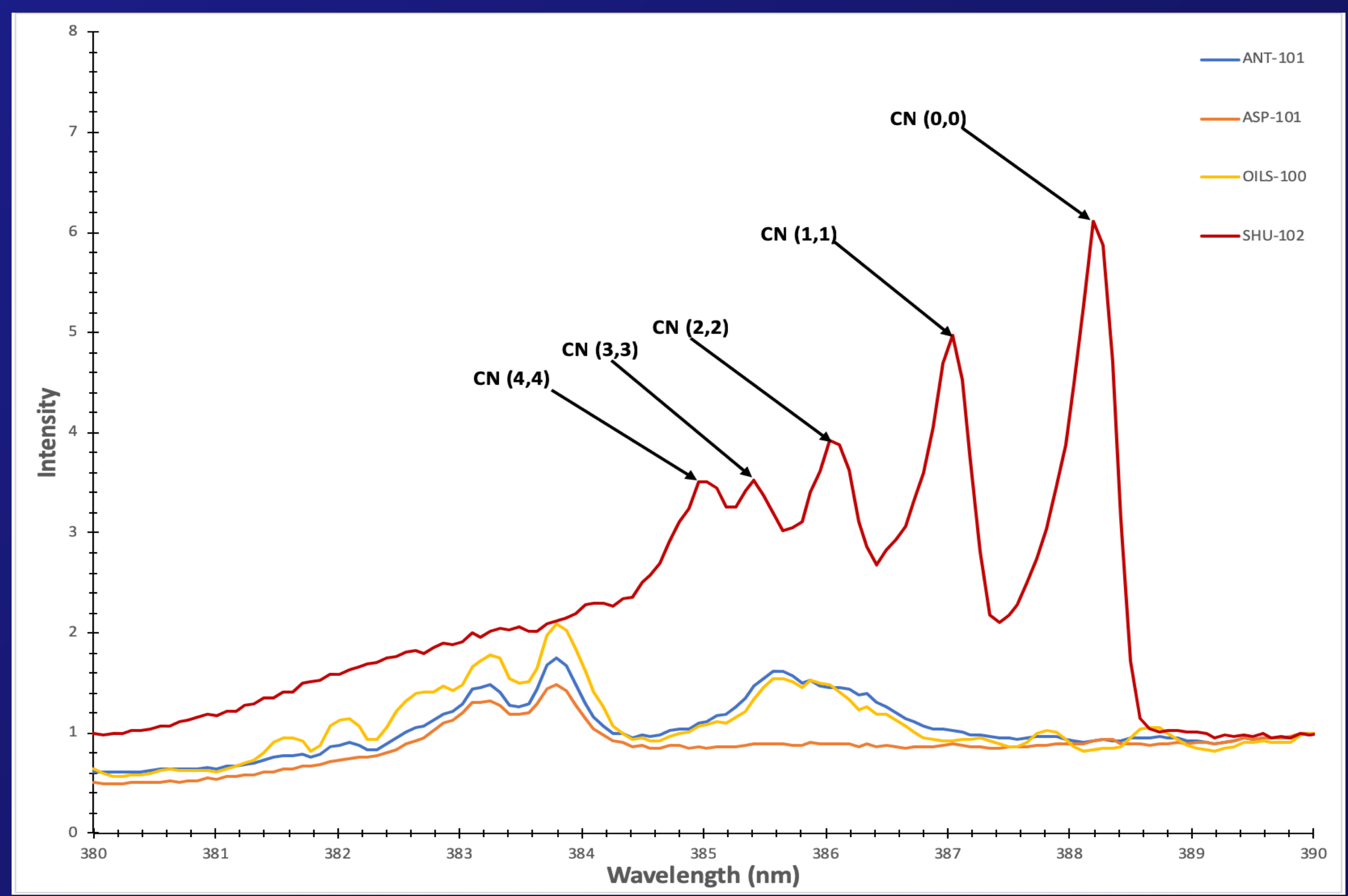

Figure 3: LIBS spectra of the molecular CN emission bands in the violet system.

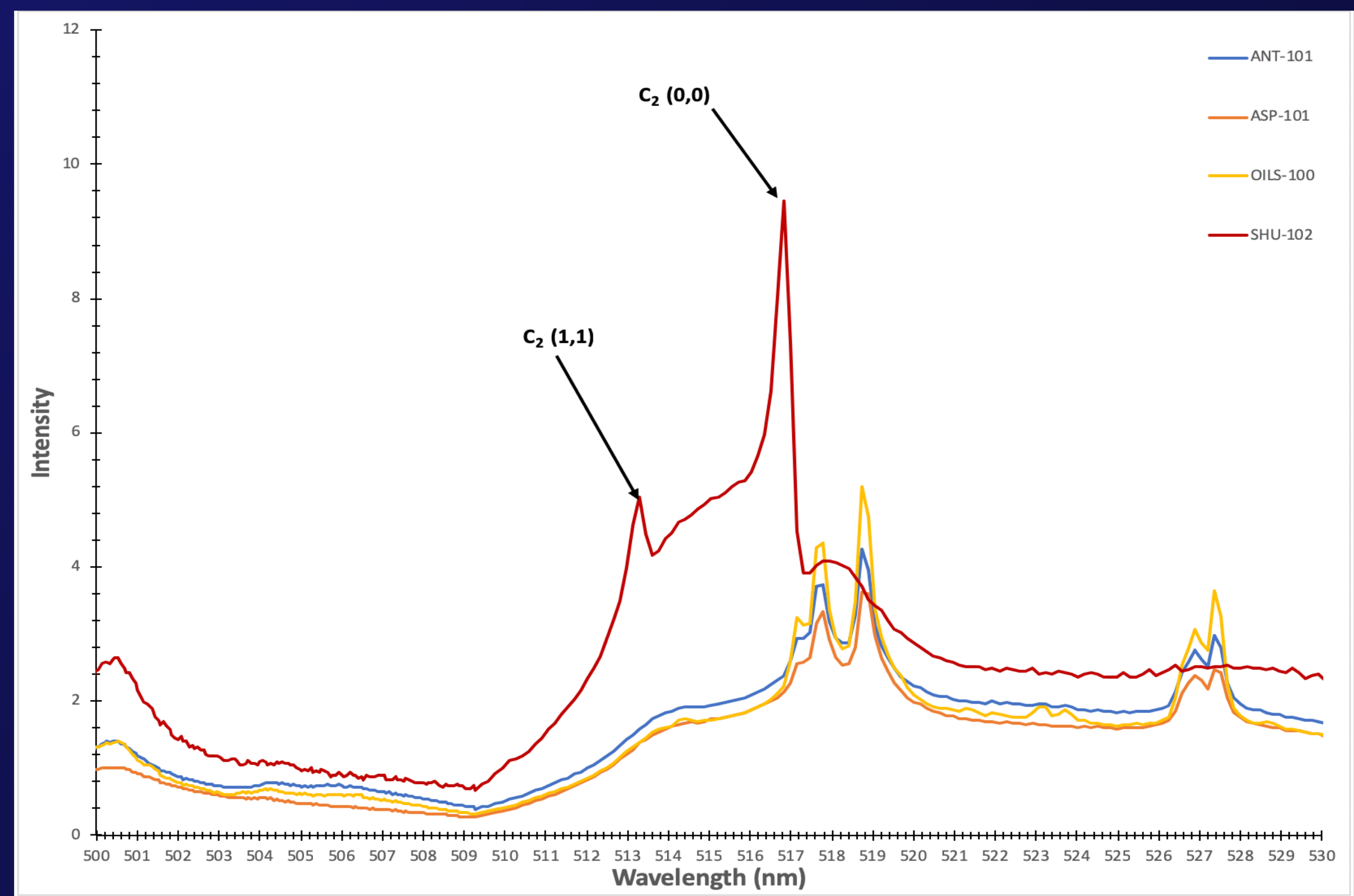

Figure 4: LIBS spectra of molecular C_2 Swan emission bands.

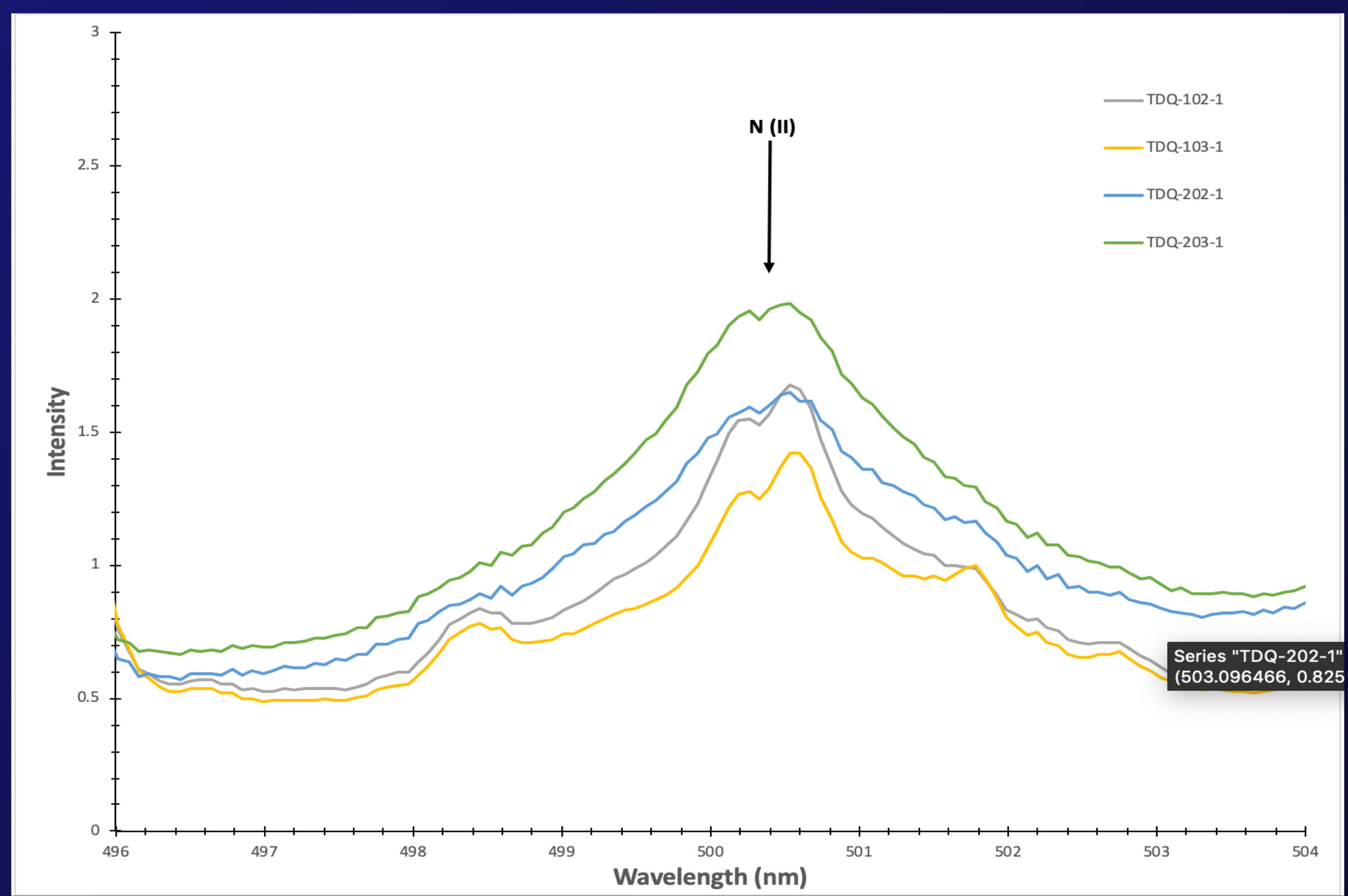

Figure 5: LIBS spectra of N (II) atomic emission lines.

Discussion/Implications:

LIBS, with its ability to identify elemental bioindicators in emission spectra, will be capable of identifying organic-bearing targets of interest similar to those included in this study [6]. NASA's upcoming plans to land the Mars2020 rover at Jezero crater will provide the opportunity to explore a deltaic environment for which analysis of samples in this terrain will rely upon SuperCam as a means of detecting biosignatures based upon elemental composition and abundances, furthering our understanding of Mars history. Therefore it is important to be informed as to the instrument's capabilities and limitations in regard to *in situ* sample analysis.

Conclusions and further work:

LIBS can detect elements of interest related to the presence of organic molecules and potential biosignatures. Further work on a larger suite of organic-bearing samples from diverse terrestrial Mars analogue environments will further improve our understanding of LIBS's ability to interrogate and characterize organic-bearing lithologies on Mars.

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Acknowledgements:This research was conducted in collaboration with MPB Communications Inc. through funding provided by the Canadian Space Agency.

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