INSTRUMENTATION AND DATA PROCESSING OVERVIEW FOR AN ULTRAVIOLET/VISIBLE/NEAR-INFRARED SPECTROMETER IN SUPPORT OF AN AUTONOMOUS ROVER FIELD CAMPAIGN. G. Holsclaw[1], A. R. Hendrix[2], F. Vilas[2], E. Z. Noe Dobrea[2], N. C. Pearson[2], and the TREX team, [1]Laboratory for Atmospheric and Space Physics, University of Colorado (Boulder, CO, USA, holsclaw@colorado.edu), [2]Planetary Science Institute (1700 E. Fort Lowell Rd., Suite 106, Tucson, AZ, 85710, USA)

Introduction: The autonomous rover project of the Toolbox for Research and Exploration (TREX), a node of the NASA Solar System Exploration Virtual Institute, SSERVI, is investigating tools and techniques designed to improve operational efficiency and science yield of future rover missions. See [1-4] for additional presentations from this project.

Among the variety of remote sensing and in-situ instruments employed by the TREX field campaign, a UV/VIS/NIR (180-960 nm) fiber-fed, non-imaging (point) spectrometer was used to collect spectral reflectance measurements of rock samples identified by the science team. Here we present a brief description of this instrument investigation, with a focus on the equipment and data processing.

Objectives: The UV/VIS/NIR spectrometer augments the Analytical Spectral Devices (ASD) fiber-fed spectrometer that covers the spectral range 350-2500 nm that was used to measure all samples. The identification of potentially diagnostic spectral features at ultraviolet wavelengths is the objective of this investigation.

Hardware: An Ocean Insight (OI, formerly Ocean Optics) custom-configured QEPro spectrograph, procured in 2019, includes a sensitive Hamamatsu S7031-1006 scientific grade, back-thinned, thermo-electrically cooled (TEC), CCD array (1044×64 format, 24 micron square pixels) with a quantum efficiency (without window) of ~65% at 200 nm and ~45% at 950 nm. The wavelength range was specified to start at 180 nm, resulting in a long-wavelength limit of 960 nm. An internal shutter, actuated via software, allows the measurement of detector backgrounds. The TEC reduces sensor dark current below detectable levels.

A dual light source (OI DH-2000-S-DUV-TTL) provides illumination from both a deuterium and quartz tungsten halogen (QTH) lamp. A manually-actuated, internal shutter is provided that blocks the output. A bifurcated fiber probe (OI QR450-7-XSR, 450 micron diameter fibers, extreme solarization resistance) combines a single read fiber to the spectrometer and multiple illumination fibers from the lamp such that the probe head contains all fibers. The probe constrains the geometry of an observation to a phase angle of 0 deg, and all observations were obtained at near-normal incidence (i=0, e=0 deg).

The rectangular entrance slit of the spectrometer can be configured; the two slit widths used were 10 and 100 micron, which result in an average spectral resolution of 1.6 and 3.6 nm, respectively.

A Spectralon diffuse standard (OI WS-1-SL) was used as the reference surface in the derivation of reflectance. Absolute reflectance is obtained through the use of a custom-made probe collar that maintains a distance of 8 mm between the probe face and the sample; a separate fixture maintains the same distance between the probe and reference surface.

A 500 Whr lithium-ion battery (Goal Zero Yeti 500X) was used to power the spectrometer, light source, and data acquisition laptop. The spectrometer, light source, and battery were all mounted to a common structure for transport to each sample site.

Data Acquisition and Processing: After arriving at a new field site, the instrument package was placed close to the sample of interest and within reach of the fiber probe. The spectrometer was powered, attaining temperature stability in less than 1 minute. One or both lamps are powered, and the first measurement was generally acquired no less than 10 minutes later; a longer duration was desired to mitigate lamp drift, but this was precluded by time and power constraints. A standard sequence of measurements was obtained for every sample observed: 1) detector background *dark1*, 2) reference *ref1*, 3) ambient background *back*, 4) sample *samp*, 5) reference *ref2*, and 6) detector background *dark2*. Repeat measurements are intended to characterize any drift in detector or lamp properties. Typically, 50 readouts were obtained for each measurement, allowing for the robust determination of random variation. For *dark1* and *ref1*, the probe was located in the reference fixture; it was then moved to the sample and placed in the sample collar for *back* and *samp*. Finally, the probe was returned to the reference fixture for *ref2* and *dark2*. For dark measurements the spectrometer shutter is closed, while for the ambient background the light source shutter is closed.

It was found that the two detector backgrounds in a set were consistent in magnitude, and the average calculated. The reference measurements were also averaged, but it was found that the first measurement was nearly always brighter than the second at wavelengths < 250 nm with a variable peak magnitude of up to ~12% at ~210 nm. The cause of this effect has not yet been determined. The magnitude of the discrepancy does not correlate with the time since the lamp was powered. Possible explanations include drifting thermal properties of the fiber probe or deuterium lamp, and the production and subsequent buildup of absorbing ozone within the reference or sample cavities.

Reflectance of a sample is calculated from the following equation:

$$R = (S_{samp} - S_{back}) / (S_{ref} - S_{dark})$$

A correction for the reflectance of Spectralon was applied.

Propagation of random errors results in a typical maximum uncertainty of ~1% at 180 nm; however, this does not capture any systematic effects, such as the drift in reference signal mentioned above.

Results: Here we highlight spectra from two samples. An image of sample A is shown in Fig. 1, and its measured spectral reflectance shown as the blue curve in Figs. 3 and 4 (same data, but shown across a smaller vertical range). This is a reddish, fine-grained sandstone and its spectrum, with several notable features, indicates the presence of hematite. An image of sample B is shown in Fig. 2 and its spectrum is shown as the orange curve in Figs. 3 and 4. This dark sample is likely a type of coal, and its spectrum appears featureless in Fig. 3. The same data shown with a truncated vertical range in Fig. 4 reveals subtle features at <400 nm, including a minimum at ~280 nm for sample B and a subsequent rise toward shorter wavelengths. Future work will correlate these features with those identified in laboratory spectra from TREX and other efforts.

Figure 1: Picture of sample A.

Figure 2: Picture of sample B.

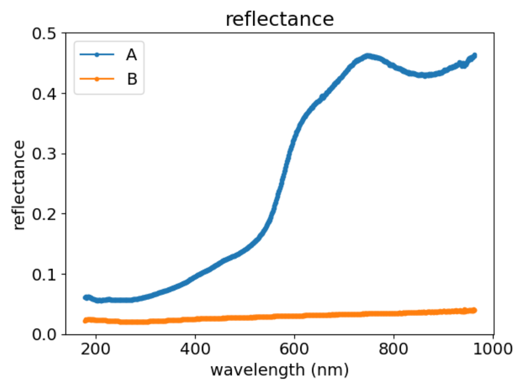

Figure 3: Measured spectral reflectance of samples A and B.

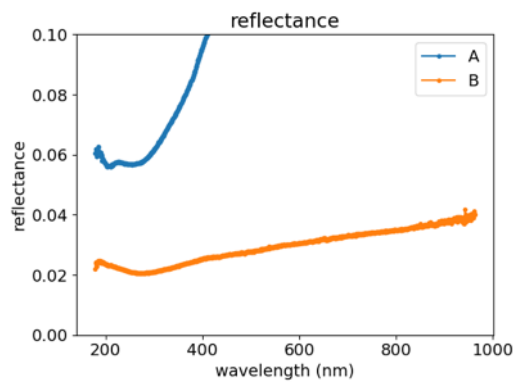

Figure 4: Same data as previous plot, but with a smaller vertical scale.

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References: [1] Noe Dobrea, E. Z., *et al.* (2021), *LPSC 2021 # 2371.* [2] Noe Dobrea et al. (2022) *LPS 1674.* [3] Clark R. N. et al. (2022) *LPS 2323*. [4] Vilas F. et al. (2022) LPS 2517. [5] Pearson N. et al. (2022) LPS 2408.