DEVELOPMENT OF THE CSI: CRISM SPECTRAL INTERROGATOR. C. E. Viviano, Johns Hopkins University Applied Physics Laboratory <Christina.Viviano@jhuapl.edu>.

Introduction: The widespread evidence for and mapping of aqueous alteration exposures across Mars (e.g., [1-3]) provides the latest drive in the search for past zones of habitability Mars, and guides landing site selection for future rovers. Despite the fact that tens of thousands of CRISM mapping (~100/200 m/pix) and targeted (~18/36 m/pix) data products exist, a standardized cataloging of detected outcrops with specific spectral signatures of aqueous alteration has yet to be established. The difficulty of cataloging the distribution and composition of these alteration phases can be attributed to: 1) the sheer volume of the available dataset to analyze, and 2) the time-consuming nature of the standard practice for identification of distinct mineralogic phases using CRISM hyperspectral data.

A total of 31 spectrally-unique phases have been identified using CRISM (over 20 of these are aqueous alteration products) and have been assembled into a type spectra library, the Minerals Identified through CRISM Analysis (MICA) Library [4]. The MICA library provides a basis for future analysis of CRISM data and summarizes the current state of knowledge in surface spectral variability. These 31 unique spectral signatures, when mapped across the surface of Mars in the full detail provided with the entire CRISM dataset, record an unprecedented level of detail about past aqueous environments on Mars. Here, we present a tool for efficiently and accurately accomplishing such a task, that we plan to complete development on and disseminate to the greater Mars science community.

Traditional CRISM analysis workflow: Typically, if using the CRISM Analysis Toolkit (CAT, http://pds-geosciences.wustl.edu/missions/mro/crism.htm) via the IDL/ENVI interface, this procedure begins by opening and linking the displays for a particular spectral parameter [4] of interest (e.g., D2300) with the full CRISM spectral image cube. The user navigates to a region where the spectral parameter has particularly high values and investigates the corresponding CRISM spectra by opening a plot window to view the "z-profile" of the image cube. Once locations of interest are identified, further investigation of the spectra from the pixels highlighted by the spectral parameter typically involves the calculation of a ratio spectra from a region of interest (ROI) to spectra from a spectrally-neutral unit within the same detector column to enhance features within the ROI spectra and eliminate scene and column-dependent noise. This step is particularly time-consuming in the ENVI environment, as each ROI must be carefully drawn within the same detector column, spectrally-neutral regions can only be identified by loading several browse composites, and each ratio must be individually calculated using the "spectral math" procedure. With over 60 standard spectral parameters and 31 potential minerals of interest, it can take hours of probing in a particularly diverse targeted observation to locate all of the spectrally-unique outcrops. Each ratioed spectrum must then be analyzed by opening up comparative spectra from a reference spectral library.

Identifying and extracting the spectra from two locations in an image using the standard workflow took ~7.5 minutes, without accounting for time it might take to identify an appropriate denominator. To recreate spectra retrieved from this type of workflow, the following must be documented: 1) image ID, 2) location of numerator and denominator spectra (row and column position within the unprojected image), and 3) dimensions of the ROIs used for each. This is only the case for standard (rectangular) ROIs and no additional undocumented processing to the spectra. This detailed documentation effort is oppressively burdensome for regional studies, adds to a time-consuming process of fully analyzing the spectral diversity of a single outcrop, and provides only the minimal information that is extractible from the dataset. ROI information documentation is often not provided in published work; typically, an arrow denotes the general location where numerator spectra were retrieved. This is detrimental to reproducibility and building upon previous efforts.

CSI Prototype: A prototype of the CRISM Spectral Interrogator (CSI, Fig. 1) has been used by several members of the APL CRISM team and their interns and student collaborators over the last ~5 years. The prototype CSI is a custom user interface that leverages widgets (graphical controls) provided by the IDL/ENVI platform. Developed in support of research projects being conducted by a handful of CRISM team members, the prototype package has analytical capabilities in order to solely meet the needs of those projects. Nonetheless, the prototype CSI has been used in several regional-scale studies, where such detailed analysis of hundreds of images would otherwise not have been possible. These studies [5,6] used this tool to identify and publish the location of thousands of outcrops with classified spectral compositions. The ability to report this level of detail in CRISM analysis is unprecedented for investigations where automated detection routines are not used. With the CSI tool, images can be probed for their unratioed and ratioed spectra, displayed with single left/right mouse clicking and automatic column alignment, ancillary metadata is automatically acquired and stored, and each location may be characterized and classified as one or more specific endmembers defined in [4]. We anticipate that the use of this tool will allow for improved global mapping and sharing between members of the Mars community. Further, the CSI will

lower the learning barrier for those familiar with spectroscopy but who may not have experience using CRISM data.

Plans: In order for the functionality of this tool to be ready to deliver to the greater planetary remote sensing community, there are several tasks left to complete. They include updating of the interface to support user-informed spectral ratioing, further development of a standard output data file format for external Geographic Information System (GIS) packages (e.g., JMARS, ArcGIS), software validation, and public release of the IDL source code (as an add-on to the CAT), and an IDL license-free VM bundle.

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References: [1] Carter, et al. (2013), *JGR*, 118(4), 831–858. [2] Ehlmann, and. Edwards (2014), *Annu. Rev. Earth Planet. Sci*., 42. [3] Pan and Ehlmann (2014), *GRL*, 41(6), 1890–1898. [4] Viviano-Beck et al. (2014), JGR, 119(6), 1403-1431. [5] Viviano-Beck et al. (2017), *Icarus*, 284, 43–58. [6] Viviano et al. (2019), *Icarus*, 328, 274-286.

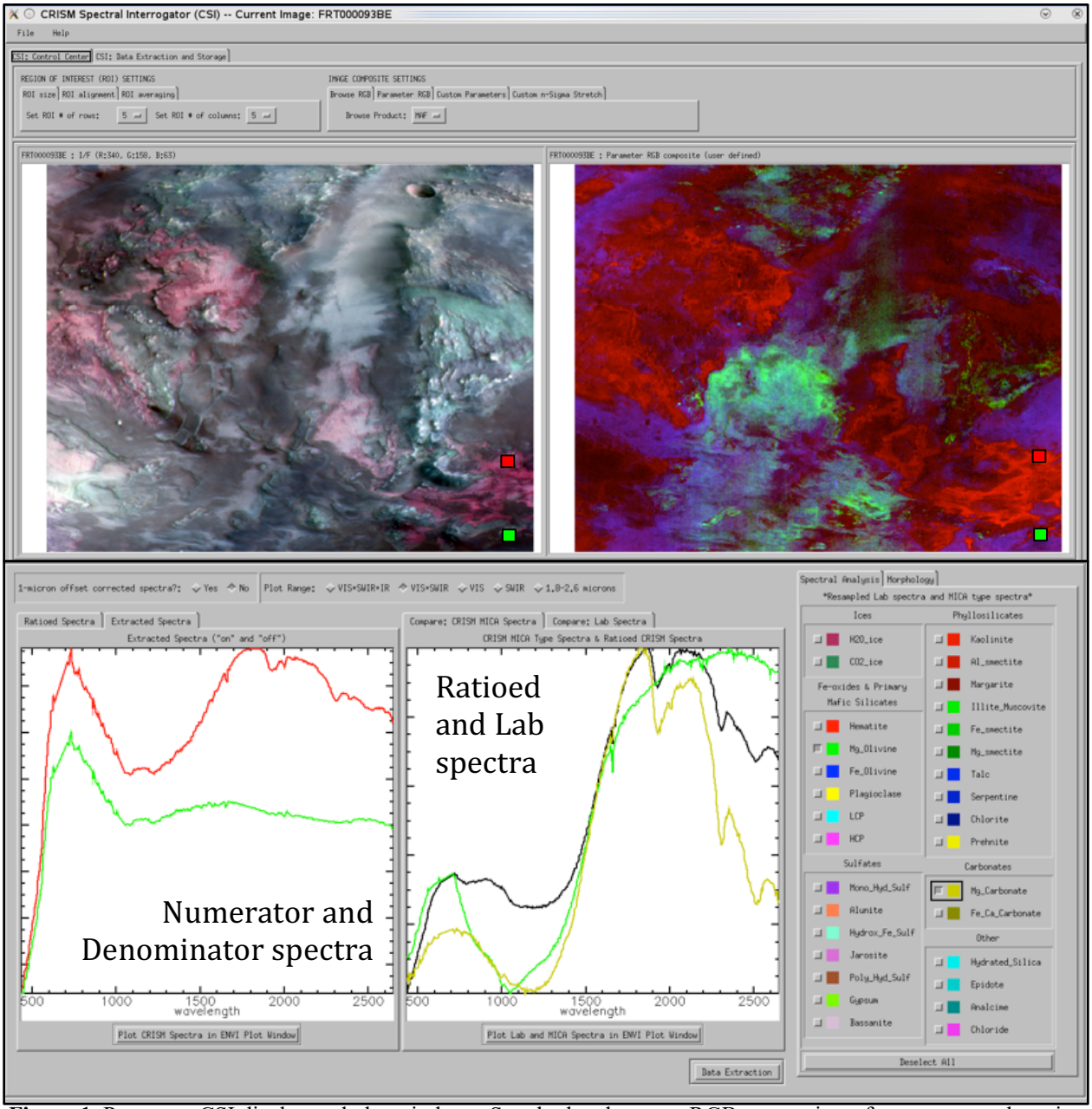

Figure 1. Prototype CSI display and plot windows. Standard and custom RGB composites of summary products in upper windows, and plots with numerator (red ROI, red spectrum), denominator (green ROI, green spectrum), and ratioed spectra (black spectrum) compared to lab and MICA spectra (green/yellow shades).