MAPPING MASTCAM MULTISPECTRAL ROCK AND SOIL CLASSES IN GALE CRATER. A. Arielle-Evans[1], M. S. Rice[1], A. Eng[1], M. St. Clair[2], C. Seeger[3], [1]Western Washington University (ariella@wwu.edu), [2]Million Concepts, Stanford University, [3]California Institute of Technology

Introduction: Mastcam is a multispectral camera on the Mars Science Laboratory Curiosity rover that has documented a variety of rocks and soils along its traverse in Gale crater, Mars. To date, Curiosity has explored over 400 meters of vertical stratigraphy, including a variety of fluvio-deltaic, lacustrine, and aeolian strata. Mastcam visible to near-infrared (VNIR) spectra can broadly distinguish between iron phases and oxidation states, and in combination with chemical data from other instruments, Mastcam spectra can help constrain mineralogy, origin, and diagenesis.

In previous work, we have compiled a database of Mastcam spectra for sols 0-2302 and quantified spectral variations across Curiosity's traverse through Vera Rubin ridge [1]. From principal component analysis (PCA) and an examination of spectral parameters, we identified 9 rock spectral classes and 5 soil spectral classes. Rock classes are dominated by spectral differences attributed to hematite and other oxides (due to variations in grain size, composition, and abundance) and are mostly confined to specific stratigraphic members. Soil classes fall along a mixing line between soil spectra dominated by fine-grained Fe-oxides and those dominated by olivine-bearing sands. In the ongoing development of the Mastcam multispectral database, we have extended these analyses through Curiosity's exploration of Glen Torridon, and find that the rock spectra from this clay-bearing unit fit within the previously-defined classes [2].

Here, we focus on mapping this multispectral data onto a Gale Crater base map. No previous studies have mapped the distribution of Mastcam's multispectral data across the Curiosity traverse. Mapping multispectral variations will create a visualization for how rock and soil classes are distributed along Curiosity's traverse, and can be compared to distributions of spectral features observed in orbital spectra and ChemCam passive data [3]. Georeferencing this multispectral data will help enable quantitative cross-comparisons between datasets in the future, and ultimately a better understanding the composition of Gale Crater.

Methods: Mastcam has a left-eye camera and a right-eye camera with fixed focal lengths (34 mm and 100 mm, respectively). Each eye has an 8-position filter wheel, and with both eyes Mastcam can acquire "spectra" in 12 unique wavelengths from ~445 to ~1013 nm [4]. Data are radiometrically calibrated to *I/F* using near-simultaneous observations of a calibration target. In each Mastcam multispectral observation, we identified regions of interest (ROIs) that are representative of the geologic and color diversity within each scene, from which we extract spectra. Extensive metadata is included with each spectrum (some assigned manually, some included from image headers). Examples of metadata are: latitude, longitude, elevation, incidence angle, LMST, rock and soil characterizations. We utilized these metadata to georeference the multispectral data in ArcPro.

This project consists of two parts. The first part focuses on building a map of Mastcam's multispectral data along Curiosity's traverse. Base maps, DEMs, and hillshade files of Gale Crater are available to download at [5]. Curiosity traverse shapefiles and metadata from the Space Exploration Dept at Arizona State University [6], are also utilized. Additional and useful metadata is found at [7].

Files and necessary data were imported into ArcPro on top of the Gale Crater base map, DEM, and hillshade. All files were georeferenced and converted to the base map's coordinate system, Mars_Equirectangular_clon0. Plotted points were organized by multispectral observations, which were positioned via rover latitude and longitude. Some rover positions have multiple observations, and each observation has multiple spectral endmembers included in the database; experimenting with how to visualize information from each spectrum separately in the same map is an integral next step in this work. Metadata information is accessible to the user and is attached to each point. Metadata is visible when a point on the map is clicked on. Images of the specified observation will be attached in each point as well. Possible image types will include decorrelation stretch images, false color images, ROIs, and raw images.

The second main focus of this project is to integrate mapping with an automated multispectral analysis workflow ("asdf", which was designed for Mastcam-Z and is currently in development for Mastcam [8]). Working with *asdf*, new scripts will automatically sweep and update the ArcPro map with the most recent Mastcam data once new spectra have been added to the database.

Results: Here we present mapping results for sols 0-2302, including all Mastcam multispectral observations through Vera Rubin ridge. Rock spectra have been assigned to one of 9 classes, and soil spectra have been assigned to one of 5 classes, as described in [1-2]. These classes each have a unique distribution along Curiosity's traverse. We only included spectra of targets within the rover workspace (< 10 m distance from the rover's mast). To remove noisy spectra, we filtered the dataset by the size of their average error bars, excluding spectra with average pixel standard deviation greater than 0.02 reflectance units.

In Fig. 1 we present rock spectral classes as two separate maps for clarity (note we excluded the Neutral/Dusty class, which is ubiquitous in Mastcam observations across the traverse). Some rock classes (e.g., Glenelg, Windjana) occur only within the early part of the traverse in the Bradbury Group. The Marimba and Hexriver classes, which have spectral signatures consistent with fine-grained hematite, are the most abundant along the traverse and occur in the Mt. Sharp Group.

Fig. 2 shows each of the five soil classes represented on one traverse map. Bradbury class soils are distributed along the traverse, while Mt. Sharp class soils have only been encountered more recently. Bagnold class soils, which have spectral features consistent with olivine [1], occur within and near the Bagnold Dune Field, a collection of dark, active mafic sands.

Discussion: From correlating the distribution of rock spectral classes with maps of stratigraphic groups, formations and members, we find that that many of the rocks that Curiosity studied within the Bradbury Group are spectrally distinct from those of the Mt. Sharp Group. We also observe distinct trends in distributions of soil classes across the traverse, suggesting that soils encountered early in the mission were largely inactive and spectrally dominated by dust and/or other Fe-oxides, whereas those later in the traverse are significantly less red and are spectrally dominated by contributions from the active, mafic dune fields [1]. We expect to encounter new classes of rock and soil as the rover gains elevation and explores the sulfate-bearing strata of Mt. Sharp.

In our ongoing work, we will make our map available online, and this multispectral map can be utilized as a tool for visual representation and understanding of the multispectral properties in the rocks and soils of Gale crater. We also plan to incorporate data from additional instruments on Curiosity for georeferenced comparisons.

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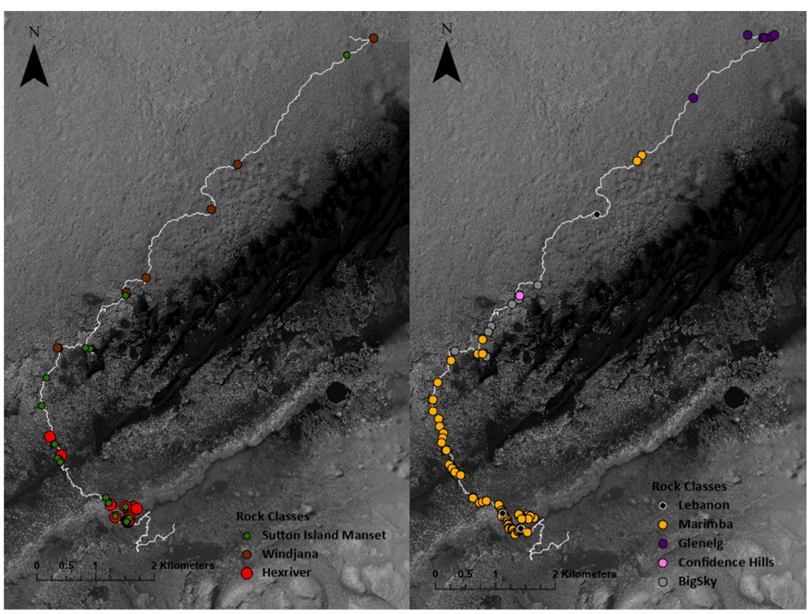

Figure 1. Distribution of rock classes [1] along Curiosity's traverse in Gale crater (sols 0-2302). Left: Sutton Island Manset, Windjana, Hexriver classes; Right: Lebanon, Marimba, Glenelg, Confidence Hills, Big Sky classes.

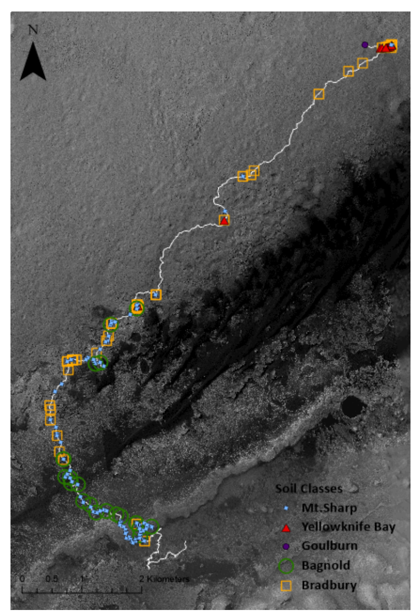

Figure 2. Distribution of soil classes [1] along Curiosity's traverse in Gale crater (sols 0-2302).