BULK MINERALOGY OF THE NORTHEAST SYRTIS AND JEZERO CRATER REGIONS OF MARS DERIVED THROUGH THERMAL INFRARED SPECTRAL ANALYSES. M. Salvatore[1], T. Goudge[2], M. Bramble[3], C. Edwards[1], J. Bandfield[4], E. Amador[5], J. Mustard[3], and P. Christensen[6]. [1]Dept. of Physics & Astronomy, Northern Arizona University, mark.salvatore@nau.edu, [2]University of Texas at Austin, [3]Brown University, [4]Space Science Institute, [5]University of Washington, [6]Arizona State University.

Introduction: Jezero crater, its watershed, and the NE Syrtis region of Mars (hereby referred to as NW Isidis) are home to several candidate landing sites for future missions to Mars. Situated within the Nili Fossae troughs and between the Isidis impact basin and the basaltic flows from the Syrtis Major shield volcano, this region contains some of the most diverse and distinctive spectral signatures observed with visible/near-infrared (VNIR) orbital datasets [e.g., 1-6]. These investigations argue that the observed alteration phases, mapped stratigraphy, and geologic contexts are consistent with the proposed global environmental transition from an early near-neutral high water:rock conditions to more acidic and low water:rock conditions [7].

While the observed spectral diversity suggests a wide range of formation and alteration environments, the bulk mineralogy of NW Isidis has never been fully explored to investigate the mineralogic context of these VNIR identifications. In this investigation, bulk surface composition in previously mapped geologic units of NW Isidis is derived using hyperspectral thermal infrared (TIR) orbital data, while more local bulk mineralogical trends are studied using higher resolution multispectral TIR data. To derive bulk composition, we utilize an iterative spectral unmixing technique developed by [8], which makes it possible to statistically assess the necessity of different endmember phases in the unmixing models. Combined with the previous VNIR studies, our results provide critical constraints on the nature and extent of surface alteration throughout the NW Isidis region.

Methods: Both the Jezero crater and watershed [4] as well as the NE Syrtis [5] regions have been extensively studied and mapped using high resolution visible imagery and Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) VNIR data. In our investigation, we obtained and processed all high-quality Thermal Emission Spectrometer (TES) spectra collected over these previously mapped units. Pixels were grouped by orbit and corrected for atmospheric effects using the NNLS minimization technique [9-10] before the derived surface emissivity spectra were averaged into a single spectrum for each geologic unit.

Averaged TES surface emissivity spectra were iteratively unmixed using a custom surface endmember library. In this method, up to ten endmember spectra are randomly removed from the endmember library, and each surface spectrum is linearly unmixed using the method of [11] to determine the best fit combination of mineral phases from the endmember library. This technique was iterated 60,000 times, randomly removing different endmembers as the algorithm progresses. The final result is an output table with the abundance of each endmember phase for each of the 60,000 runs for each previously mapped geologic unit. Endmembers were aggregated into endmember groups to simplify data interpretation. Using these data, it is possible to derive average surface compositions and model uncertainties, and to assess the distributions of modeled endmember abundances.

In addition to the relatively low spatial resolution of TES (~3 × 6 km/pix), higher resolution (~100 m/pix) multispectral TIR data from the Thermal Emission Imaging System (THEMIS) instrument were used to identify subtle changes in overall silica content across the landscape of NW Isidis. This is accomplished through mapping the Weighted Absorption Center (WAC) of the major TIR reststrahlen features [12-13]. Because more silicic and mafic lithologies trend towards shorter- and longer-wavelengh WAC values [14], we are able to assess relatively local variations in composition and to place these variations into the regional geologic framework.

Results: While VNIR data show a wide variety of alteration mineral phases indicative of a similarly wide variety of alteration environments, our TIR unmixing analyses indicate dominantly basaltic compositions with relatively minor mineralogical variability. All previously mapped geologic units are roughly composed of 15-25% plagioclase, 20-30% pyroxene, 15-30% phyllosilicates and amorphous components (PAC), and 15% sulfates, while other minor primary or secondary phases are present at or below ~10%. The modeled abundances of each endmember group in each geologic unit is shown in **Figure 1**, which also shows the relative distribution of model results.

The dominance of basaltic compositions in NW Isidis is confirmed by THEMIS WAC parameter values throughout the region, which suggest dominantly basaltic compositions with variable enrichments in olivine (**Figure 2**). The relationship between higher WAC values and increased olivine abundance is confirmed when comparing VNIR spectral signatures to the WAC parameter, where stronger olivine signatures in CRISM data are correlated to higher WAC values, as expected. Several small (< 1 km^2) exposures of very low WAC values were identified in the Jezero watershed, and are similar in appearance and distribution to those identified by [13] in the nearby Nili Fossae region. These exposures are predicted to contain

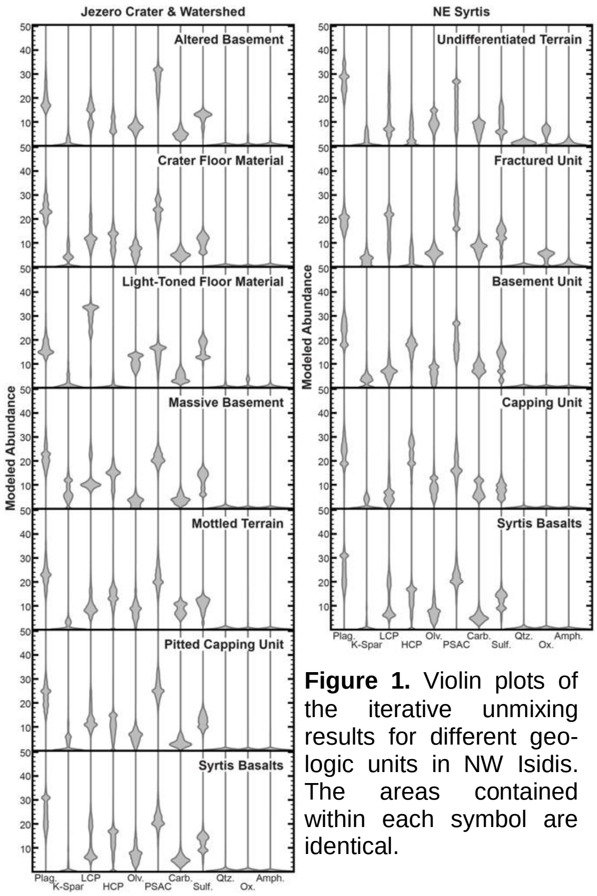

Figure 1. Violin plots of the iterative unmixing results for different geologic units in NW Isidis. The areas contained within each symbol are identical.

high-silica abundances, and comparisons to laboratory data suggest compositions consistent with monzonite.

Of particular interest throughout the NW Isidis region is the VNIR identification of carbonates associated with the Fractured Unit (FrU) of NE Syrtis [5] and the Mottled Terrain (MT) of the Jezero watershed [4]. The iterative unmixing suggests that these two units contain, on average, 8.8% and 9.1% carbonate, respectively, which are just below the traditionally accepted TES detection limit of ~10%. Iterative unmixing of each individual TES observation in the FrU of NE Syrtis reveals modeled carbonate abundances between 3.5% and 16.5%, suggesting significant spatial variability in the presence of carbonate. This observation is consistent with the VNIR observations of [5], who show that strong carbonate signatures are present largely in small bedrock exposures and are muted elsewhere due to limited exposure or mantling.

Discussion & Conclusions: TIR spectral analyses confirm that the NW Isidis region is dominated by basaltic compositions with variable amounts of alteration mineral phases. These results help to put the diverse alteration phases identified with CRISM data into geologic and compositional context. For example, aqueous alteration that occurred when these geologic units formed and altered was insufficient to thoroughly alter primary basaltic compositions, which still preserve mineral phases that are readily susceptible to chemical weathering (e.g., olivine).

Comparisons between different orbital and landed missions have shown that observed compositional diversity increases with improved spatial resolution. While CRISM observations of NW Isidis reveal the spectral dominance of many different mineral phases, mineralogical variations identified by lower resolution TIR datasets are far more muted. This suggests that future landed missions to NW Isidis would likely identify many diverse altered compositions and would be able to place these observations into better geologic and stratigraphic context. Fortunately, both Jezero crater and NE Syrtis are candidate landing sites for future missions to Mars.

Lastly, this demonstration of the iterative unmixing technique for regional-scale compositional analyses confirms its utility for critically evaluating unmixing model results and provides additional information on the distribution of model results and the robustness of endmember detections. Whether for investigating the presence of specific mineral groups [8] or bulk composition (this study), iterative unmixing is useful for assessing the performance of TIR unmixing models.

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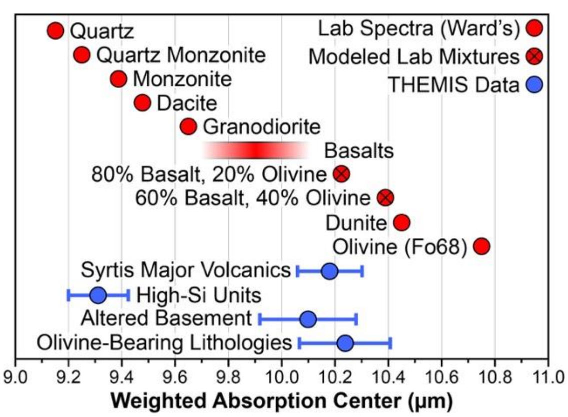

Figure 2. WAC values for laboratory (red) and orbitally derived spectra (blue). Bars surrounding average THEMIS measurements (circles) represent minimum and maximum recorded values.