MINERALOGICAL ASSESSMENT OF VOLCANIC EDIFICES ON MARS USING NEAR- AND THERMAL INFRARED REMOTE SENSING. J. C. Lai[1], B. Horgan[2], and J. F. Bell III[1] [1]School of Earth and Space Exploration, Arizona State University (jcslai@asu.edu), [2]Department of Earth, Atmospheric, and Planetary Sciences, Purdue University.

Introduction: Many of the largest volcanoes on Mars are located in high-albedo regions. These regions are spectrally bright due to mantling by surface dust, which masks the absorption features used to infer mineralogy in both the near- and thermal infrared [1-3]. As a result, the classical martian bright regions of Arabia Terra, Elysium Planitia, and Tharsis remain uncharacterized in detail with respect to mineralogy [4]. However, there are localized areas within these dusty regions where the dust cover is removed at varying time scales to expose the dark underlying substrate. These areas can serve as "windows" through the dust, allowing us to obtain higher quality mineralogical information via near- and thermal infrared spectroscopy.

Here we present examples of near-infrared mineralogical analyses of dust-free "windows" that are associated with volcanic edifices. Some of Mars' largest volcanoes are located within very bright regions, including Alba Patera, Elysium Mons, Olympus Mons, and Tharsis Montes. Their capacity for erupting large amounts of material onto the martian surface as volcanic ash [5] or glass [6] in addition to lava flows makes understanding the composition of the crust at and near these locations critical for reconstructing the planet's volcanic history.

Methods: Dust-free surfaces were identified using two methods. The Dust Cover Index (DCI) derived from Thermal Emission Spectrometer (TES) data uses emissivity in the 1350 to 1400 cm^{-1} wavenumber region to determine the amount of dust present on Mars' surface [7]. Because the atmosphere is transparent in this region, emissivity can be solely attributed to the particle size of the silicate minerals at the surface. TES pixels appearing in large dusty regions that also match the parameter constraints defined by the DCI were mapped and targeted for further analysis.

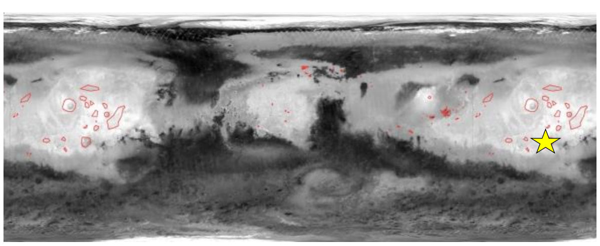

Figure 1. TES global albedo map showing the locations of dust-free surfaces identified to date outlined in red. The yellow star denotes the location of Arsia Mons.

The DCI is a static map, so an alternative method is needed to search for dust-free surfaces that are shorter-lived. The Mars Color Imager (MARCI) takes repeated visible-wavelength images of most of the surface every Mars day, allowing us to make small regional mosaics that identify areas with time-variable albedo during short time intervals. Previously mosaicked and sequenced MARCI quadrangles were used to distinguish areas that undergo significant darkening due to dust-clearing events [8].

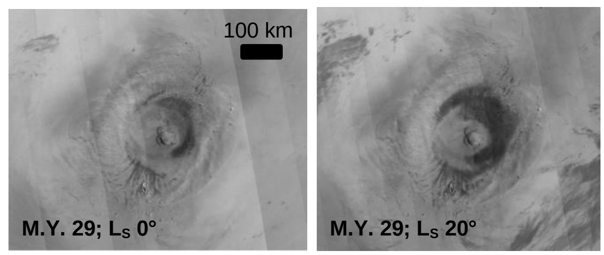

Figure 2. Successive MARCI observations from early spring of M.Y. 29 reveal significant darkening of the flanks of Ascraeus Mons and adjacent plains in Tharsis.

Because we are especially interested in analyzing bedrock, we used night versus day temperature contrast derived from Thermal Emission Imaging System (THEMIS) images to differentiate between rocky and sandy surfaces. Context Camera (CTX) images were used to determine local morphology, such as identifying the presence of sand dunes or stratigraphic layering.

Once identified using either the DCI or MARCI, areas of interest were analyzed with near-infrared reflectance spectra from the Observatoire pour la Mineralogie, l'Eau, les Glaces et l'Activité (OMEGA) onboard Mars Express [9]. OMEGA images taken from approximately the same time as the corresponding DCI/MARCI observation were selected from previous mapped and calibrated quadrangles. If OMEGA data from the same timeframe was unavailable, data taken during the same L_S range from other Mars years were used, as the observed dust-clearing events appear to occur on an annual cycle. The spectra were then ratioed with a nearby dusty reference region to amplify spectral features, smoothed, and continuum removed. We used band ratios from pre-existing spectral parameters to search for common iron-bearing minerals in the martian crust: low-calcium pyroxene (LCPINDEX), high-calcium pyroxene (HCPINDEX), and olivine (OLINDEX2) [10, 11]. We also parameterized the position of the 1 and 2 µm absorption bands of these spectra and compared them to laboratory-derived results to help constrain mineralogy [12].

We will also corroborate the OMEGA near-IR results with deconvolved TES thermal emission spectra. Although we begin by following the quality constraints defined by Rogers, et al. (2007) [13], the scarcity of low albedo TES spectra within the dusty regions investigated in this study will likely require loosening those constraints.

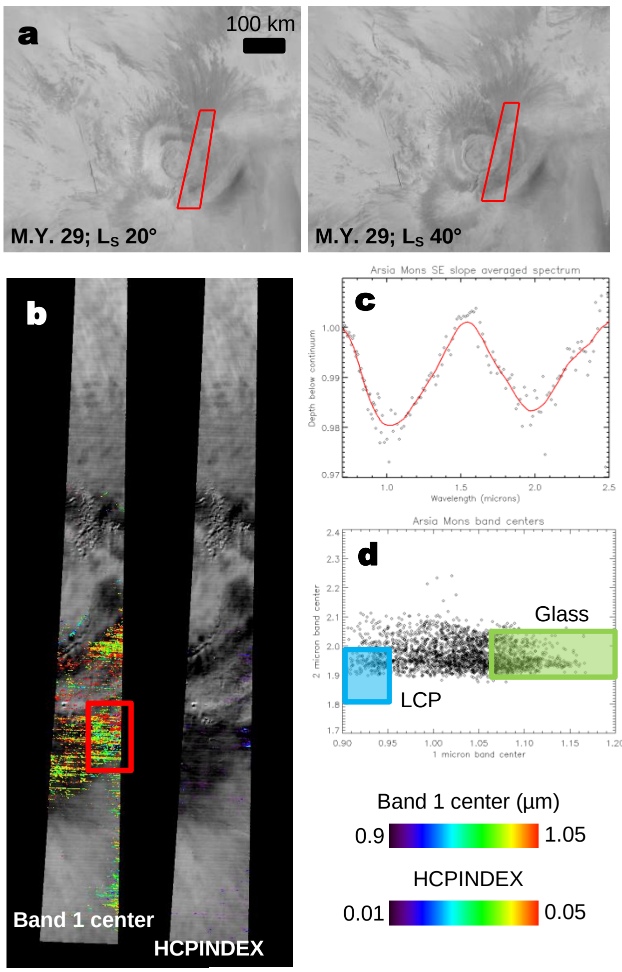

Figure 3. (a) MARCI observations from the spring of M.Y. 29 showing the darkening of the flanks of Arsia Mons. Red box denotes the location of 3b. (b) Band 1 center (left) and HCPINDEX (right) parameters mapped over OMEGA visible image from the same time of year as 3a. Only pixels with band 1 depth greater than 2% are mapped. Red box denotes the area investigated in 3c and 3d. (c) Averaged spectrum for pixels located within the red box in 3b. (d) 1 vs. 2 µm band center plot for pixels within the red box in 3b. Colored parameter regions are derived from laboratory spectra [12].

Initial Results: Of all the areas of interest investigated thus far, Arsia Mons exhibits the most promising mineralogical signatures. MARCI observations reveal darkening of the flanks in the spring of M.Y. 29. Parameterizing and mapping the 1 µm band position reveals that spectra that fall within the range associated with iron-bearing minerals have good spatial coincidence with dark material exposed during the dust-clearing event. Spectra located within the dark area fall between the LCP and glass parameter space in the corresponding 1 vs. 2 µm band center plot [6, 12]. Similar techniques have been used in areas of interest located in other dusty regions, such as Ismenius Cavus in northern Arabia Terra and Pettit Crater at the Amazonis and Elysium Planitiae boundary.

Discussion: The possibility of glass in Arsia Mons is consistent with recent detections of widespread weathered iron-bearing glass deposits in the northern lowlands, which has been suggested as evidence for explosive volcanism playing a significant role in Mars' geologic history [5, 6]. Previous studies on explosive volcanism on Mars have proposed Tharsis Montes as a likely source of layered ash deposits due to the thinning of such material with increasing distance from Tharsis [5]. Our detection of LCP is unexpected, as LCP is typically localized to Noachian-aged cratered terrain [2]. Additional analyses of Arsia Mons following different dust-clearing events will help to further assess this result and determine the extent of these potential LCP detections. We will use the same spectral analysis techniques to characterize the mineralogy of the most prominent volcanic edifices on Mars, especially in the Tharsis region.

References:

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