REGIONAL MAPPING AND SPECTRAL ANALYSIS OF MOUNDS IN ACIDALIA PLANITIA, MARS.

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Introduction: Acidalia Planitia is a ~3,000 km diameter planum located in the northern plains of Mars. It is believed to be a sedimentary basin containing an accumulation of sediments brought by Hesperian outflow channels that drained the Highlands. A large number of high-albedo mounds have been identified across this basin [1-2] and understanding the process that formed them should help us understand the history of this region.

Farrand *et al.* [2] showed that the mounds are dark in THEMIS (Thermal Emission Imaging System) nighttime IR (infrared) image data. This implies that the mounds have a lower thermal inertia than the surrounding plains (Fig. 1), suggesting that the material of the mounds is fine-grained or unconsolidated. Farrand *et al.* [2] also reviewed potential analogs for the mounds and concluded that a combination of mud volcanoes with evaporites around geysers or springs is most consistent with all the data.

We have built on this work by creating regional maps of the features and analyzing CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) data to see if there are mineralogical differences between the mounds and surrounding plains.

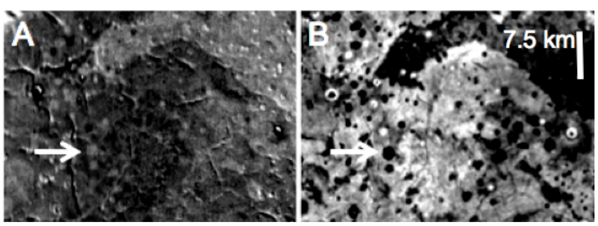

Fig. 1. Acidalia Mounds. (A) THEMIS daytime IR image and (B) the same area in THEMIS nighttime IR. Arrows point to the same mound in A and B.

Methods: *Regional Mapping, Size and Relief.* THEMIS images were analyzed using ArcGIS software with image mosaics and geological maps that were included in the USGS Mars DVD v 1.4. Dark mounds larger than three pixels (~300 m) in nighttime IR images were mapped. Approximately 45% of southern Acidalia was surveyed; much of the northern part of Acidalia lacks good image data and mapping was not possible there. Spatial densities were calculated across southern Acidalia by counting the number of mounds in the three areas shown in Fig. 2. Areas used ranged in size from 22,000-29,000 km^2. Average mound diameters were determined by analyzing four separate 1,000 km^2 areas, measuring the diameters of the mounds within each area, and averaging them.

CRISM. We analyzed nine CRISM images covering areas in Acidalia with mounds identified in HiRISE (High Resolution Imaging Science Experiment) images. CRISM images were processed to remove atmospheric and instrumental noise, and spectra from the mounds were ratioed to spectra from surrounding plains. Both the VIS (visible) (0.4-1.1 μm) and NIR (near-infrared) (1.1-2.5 μm) wavelengths were evaluated. In each CRISM image 5-11 ratios were created. Those ratios were then averaged to create one ratio to represent each image (Fig. 3).

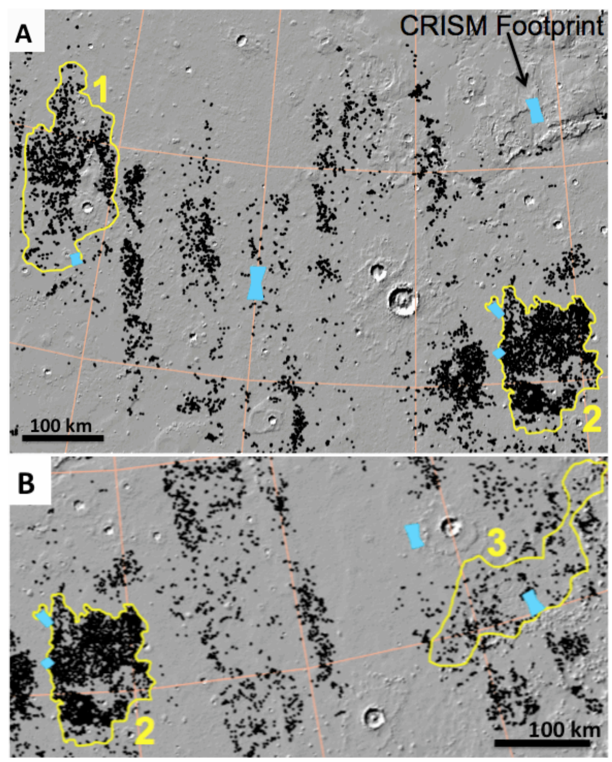

Fig. 2. Mapped Region in Acidalia. Mapped mounds (black dots); A, Western region; B, Eastern region. Polygon 2 in each shows overlap of A and B. Footprints of 7 of the 9 CRISM images used (blue rectangles). Footprints of 2 of the CRISM images used are beyond the extents of A and B. MOLA altimetry background.

Results: More than 18,000 mounds were mapped in southern Acidalia. Spatial densities ranged from 21-114 mounds per 1,000 km^2 and diameters ranged from 0.81 km to 1.06 km, with an average of 830 m. Area 1 contains mounds associated with arcuate ridges. Area 2 has mounds associated with muted polygons and has the greatest spatial density of mounds among the three areas. Area 3 has large, (~5-15 km across) polygons; this area has the lowest spatial density of mounds, but the largest average mound diameter of 1.06 km. CRISM ratio analyses showed that the mounds and plains are similar in NIR wavelengths (Fig. 3). However, in the VIS wavelengths, ratios derived from all nine images showed that the mounds have a positive slope from 0.4-0.65 µm, indicating enhanced concentrations of ferric iron in the mounds (Fig. 3). This result is similar to that obtained in previous analysis of CRISM image 3837 [3].

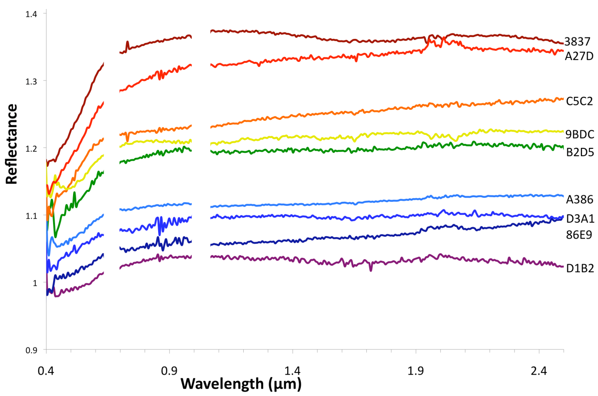

Fig. 3. CRISM Ratio Spectra. Each spectrum represents the average ratio of mounds to representative samples of the plains in that particular CRISM image. CRISM ID on right.

Discussion: Our mapping illustrates the abundance and distribution of mounds across Acidalia. With over 18,000 mounds identified in only a portion of the basin, we estimate that there may be at least 40,000 mounds in southern Acidalia. This abundance suggests that the mounds represent a major geologic process in the northern plains. The fact that our mapped mounds are limited to the Acidalia basin suggests that their origin may correlate with some aspect of the geology of this particular basin [4]. Most mounds superimpose the Early Amazonian Vastitas Borealis Interior and Marginal units of the northern plains [5] and are therefore among the youngest features in Acidalia.

Our density calculations, which range from 21–114 per 1,000 km^2, are consistent with a terrestrial mud volcano analog. Azerbaijan has one of the highest concentrations of mud volcanoes on Earth. Spatial densities there range from 20-40 mounds per 1,000 km^2, mud volcano diameters range from approximately 1-10 km, and mud volcano heights range from approximately 100-500 m.

The VIS portions of CRISM ratioed spectra showed significant differences between the mounds and the plains. The positive slopes from 0.4-0.65 µm imply that the mounds have more ferric iron than the background terrain, and this would be consistent with an interpretation that the mounds are more oxidized than the plains.

In contrast, there were few differences between the mounds and plains in the NIR portion of the CRISM data. This may be similar to other observations of muted NIR responses for material in the plains of Acidalia [6] and might be explained by the following: 1) the mineralogy of the mounds may be different from that of the plains but possibly occurs in a concentration too low to be detected from orbit, 2) minerals in the mounds may not have spectral signatures in the CRISM wavelength range, 3) the mounds may be comprised of amorphous material which does not have a spectral signature, or 4) spectral signatures of the mounds may be masked by an alteration layer.

These CRISM results would be consistent with a mud volcano analog as mud volcanoes would be expected to be similar in composition to materials of the plains but might also show enhanced oxidation due to subsurface fluid interactions.

Summary: High-albedo mounds in southern Acidalia Planitia, Mars appear to best resemble terrestrial mud volcanoes. Over 18,000 of these mounds have been mapped in the region. They have indications of low thermal inertia, as well as spatial densities and diameters consistent with a mud volcano analog. Analysis of CRISM data supports this model in that the mounds are more oxidized than the plains, potentially reflecting enhanced alteration within fluid-rich sediments.

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References: [1] Allen, C., Oehler, D. (2009). AGU. Eos 90 (52) 29 Dec 2009., Abs. P41B-04 [2] Farrand, W.H. *et al.* (2005) JGR, 110, E05005, doi:10.1029/2004JE002297. [3] Allen, C.C., Oehler, D.Z., Baker, D.M., 2009, LPS XL, Abs. #1749. [4] Oehler, D. Allen, C. (2010) LPS XLI, Abs. #1009. [5] Tanaka, K.L., Skinner, J.A., Jr., Hare, T.M, 2005. USGS Scientific Invest. Map 2888. [6] Salvatore, M. R., Mustard, J. G., Wyatt, M. B., Murchie, S. L., Barnouin-Jha, O. S., 2009. LPS XL, Abs. #. 2050.