EPSC Abstracts,
Vol. 4, EPSC2009-679, 2009
European Planetary Science Congress,

Surface units of Mars analyzed with spectral, color and stereo images. II: Gusev

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Introduction: Surface color units and photometric effects

The spatial distribution of dark materials on Mars is usually not clearly related to well-defined sources. Tracking their origin requires detailed mapping of the major surface units. Bright red and dark materials are the most common of those that can be detected with the High-Resolution Stereo Camera (HRSC, [1]) on Mars Express. The present work relies on the same methods of analysis presented in a companion abstract [2]. We are trying 1) to extend findings of the rover Spirit and high-spatial resolution remote sensing data that have limited spatial coverage and 2) to detect additional units at Gusev. Additionally, the different orientation of each color camera makes HRSC five-channel spectra sensitive to effects that are non-equivalent from wavelength to wavelength due to atmospheric scattering and surface roughness. Therefore, besides composition, spectra are also sensitive to shading and surface roughness.

The surface of Mars at Gusev

Basaltic sands

Dark materials on Mars are mostly of basaltic composition, and thus of volcanic origin. They are frequently more concentrated on the sides of topographical structures with positive relief like crater rims, where they form a tail, likely due to eolian deposition. They are also present in large abundances in topographical lows like crater interiors. These may be eolian deposits that cannot escape. This raises the possibility of sources underneath the surface. At Gusev (Fig. 1a), they also appear, exposed by dust devil tracks (Fig. 1d,e) as evidence that dark basalts are covered by a thin layer of bright red dust.

Surface roughness

Surface roughness at Gusev has already been investigated using THEMIS observations [3] and photometry by HRSC stereo data [3, 4, 5, 6]. The comparison with results derived from HRSC color data will help to better characterize the photometric properties.

Spectral Mixing Analysis of HRSC color data

The SMA [7, 8] is performed by using endmember spectra that are representative of the two major components: bright red material (often iron oxide-rich dust) and dark basaltic sands. A spectrum of shade is calculated using surfaces that appear homogeneous in composition and that possess gradients of shade (local incidence angles vary). Mixing coefficients are constrained to be strictly positive and their sum has to equal unity [9, 10, 11]. Fig. 1b shows the image fraction of dark and bright materials. Fractions of shade (Fig. 1c) provide estimates of roughness. However, as geometric conditions vary across the image, the spectrum of shade is generally not unique, which generates higher residuals of the SMA. High residual values that form a coherent unit may reveal a new surface type, which could eventually be characterized.

Quantitative mapping of basaltic materials

Dark basaltic materials have spectral signatures in the wavelength range 400-1000 nm that are different enough from the ubiquitous bright red dust to be detected and mapped with HRSC color data. Therefore, the SMA is a tool suited for mapping relative abundances, assuming linear spectral behavior of aerial mixtures. Gusev is a region where only the red and dark units can be mapped with HRSC (Fig. 1b). Mapping of contours and concentration of basaltic deposits may aid in the discovery of their source [12, 13],

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which is of geological interest. The capacity to distinguish additional minerals has been shown to be limited in the multispectral analysis of visible light on Mars, despite some successes achieved in regions that show more spectral diversity [12].

Surface roughness

Large rocks are capable of casting large shadows, and therefore contribute greater amounts of shade than smaller particles. Thus, low residuals interpreted as low amounts of shade are more likely representative of areas relatively free of larger rocks. In Fig. 1c, high amounts of shade appear dark, which is more intuitively associated with shade. Fractions of shade correlate highly with shaded relief. At the rover Spirit landing site, low shading is consistent with moderate roughness that is found in the absence of large rocks.

Conclusion and perspectives

We have demonstrated that HRSC color data contain information about the topography at scales smaller than a pixel. Since surface roughness is only a secondary product of the analysis of HRSC color data, specific investigations should combine this analysis with stereo images. Comparisons with surface roughness-specific studies [3, 4, 5, 6] will be used to improve interpretations of the aforementioned effects.

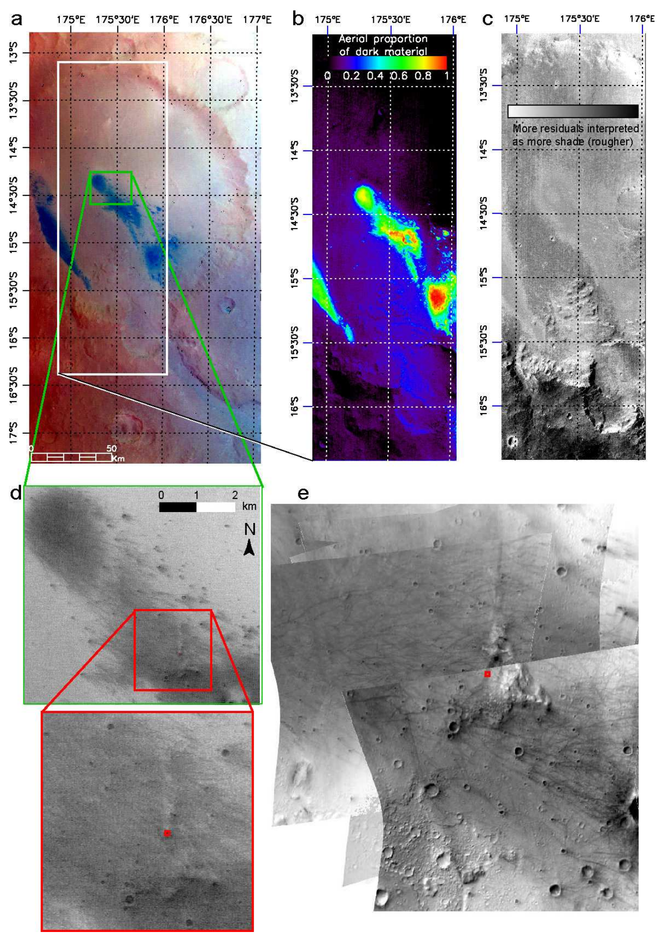

Figure 1: The surface of Mars at Gusev as seen from orbit. a – HRSC color composite at 750, 530 and 440 nm from image h0072_0000_4_11. b – Image fraction of dark basalt-rich material. c – Image fraction of shade that shows sensitivity to surface roughness. d – HRSC nadir image at full resolution centered on the Columbia Hills. d – Mosaic of 8 targeted CRISM dataset at 1330 nm centered on the Columbia Hills.

References

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Acknowledgements

Work supported by the HRSC team and the NASA Mars Data Analysis Program NN-X07AZ37G