THEMIS DECORRELATION STRETCHED INFRARED MOSAICS OF CANDIDATE 2009 MARS SCIENCE LABORATORY LANDING SITES: EVIDENCE FOR SIGNIFICANT SPECTRAL DIVERSITY. V. E. Hamilton, M. M. Osterloo, and B. S. McGrane, Hawai'i Institute of Geophysics and Planetology, University of Hawaii, 1680 East-West Road, POST 504, Honolulu, HI 96822; hamilton@higp.hawaii.edu.

Introduction: Decorrelation stretched (DCS) color infrared (IR) images are an effective means of evaluating compositional variations on the Martian surface. Using data from the 2001 Mars Odyssey Thermal Emission Imaging System (THEMIS) [1], we have produced 3° x 3° DCS IR mosaics of the 33 sites proposed as candidate landing sites for the 2009 Mars Science Laboratory mission. These mosaics (available at http://themis.asu.edu/landingsites/) may be used to evaluate the geology in the vicinity of the proposed landing sites. Many mosaics display variations indicative of diverse mineralogies.

Data & Processing: The THEMIS IR subsystem images Martian radiance in nine channels (each ~1µm wide) from ~6 – 14.5 µm. The resulting multispectral data can be used to study Mars' atmosphere, surface mineralogy, and thermophysical properties. For rapid assessment of spectral variation, DCS processing enhances color differences between channels by removing highly correlated information [2]; a color image is produced by assigning three channels to red, green, and blue (RGB), respectively. It is rare for surfaces to exhibit spectral differences in only one channel, so the RGB channels usually exhibit variable values that combined, produce colors such as yellow (red + green), cyan (green + blue), and magenta (red + blue).

The IR radiance images we used to make the mosaics were selected to have the highest possible surface temperatures and to avoid yawed images and data acquired as part of atmospheric campaigns, but full coverage of sites took precedence. We display calibrated radiance bands 8 (11.79 µm), 7 (11.04 µm), and 5 (9.35 µm) in red, green, and blue, respectively (an 8-7-5 DCS). We applied several standard data processing steps [1, 3] as well as additional steps designed to cosmetically improve the overall appearance of the data. We used ISIS to project images into either sinusoidal (polar regions) or simple cylindrical projections, and then mosaicked the images. After mosaicking, we used a script written for the Davinci software package (http://davinci.asu.edu/) to perform a running DCS, which performs an individual DCS on every sub section of the array as defined by an x and y dimension. Half of each section overlaps an adjacent section and is used to blend the data with the goals of minimizing visible seams, enhancing local variations, and maintaining the continuity of the DCS across the image. Because these are radiance images, the effects of temperature have not been removed and color intensity/brightness variations (e.g., light vs. dark blue) probably indicate differences in temperature (resulting from albedo and/or particle size variations) rather than composition. Differences in hue (e.g, blue, magenta, green) are more likely to be related to composition.

Using Mosaics for MSL Candidate Landing Site Characterization: THEMIS DCS mosaics are a visualization tool intended for use in identifying compositional variations on the Martian surface. Because these images contain highly manipulated data, no quantitative information can be extracted from them. However, they can be used for relative compositional distinctions, to identify locations where it may be desireable to retrieve multi- or hyperspectral data for quantitative analysis, and to map out the coincidence of compositional variations with other features, such as thermal inertia or geomorphology. The 8-7-5 DCS tends to show the mafic (commonly olivine-bearing) materials as pink/magenta in color, whereas relatively felsic materials tend to be yellowish. (Sulfate band positions commonly coincide with those of more felsic silicates and may be expected to appear yellowish in an 8-7-5 DCS image.) In general, compositional variations tend to correlate with geomorphology. Other features, such as artifacts and atmospheric phenomena, generally do not exhibit such correlations.

Artifacts. Artifacts are present in some of the DCS mosaics; generally they are spatially restricted, but users should be aware of their characteristics so that they are not erroneously attributed to surface mineralogy. (In cases where the artifacts significantly detract from the utility of the image, mosaics will be updated as higher quality data become available.) Artifacts may result from corrupted or missing data within an image or attempts to mosaic adjacent images acquired at different seasons or times of day (these mosaics sometimes exhibit variable shadow lengths). Some artifacts are well defined linear strips having coloration that differs significantly from the adjacent pixels, "seams", and color variations oriented along-track (~NNE-SSW direction, e.g., Hale crater mosaic). Data gores within an image (missing lines) result in artifacts that are oriented across-track (~E-W) and may be a black line or an oddly-colored, noticeably artificial line (e.g., Nili Fossae crater mosaic). Shadows or sunlit slopes may appear saturated in one color if the data are saturated in that channel (e.g., some crater/canyon walls). Some artifacts result from extreme variations in surface temperature that are not corrected by the standard data calibration. These appear as intense blotches of color that do not correlate with geomorphology (e.g., Juventae Chasma mosaic). As a general rule, if a feature looks unnatural, it may be an artifact and should be interepreted with caution.

Atmospheric effects. Water ice clouds and changes in dust opacity associated with extreme changes in topography may be mistaken for compositional variations on the surface if they are not recognized. In the 8-7-5 DCS, clouds are blue, tend to have diffuse edges, are irregular in shape, do not correlate with geomorphology, and generally do not cross image boundaries (i.e., end abruptly to the left or right within the mosaic, see Becquerel crater). Color variation associated with clouds may resemble some along-track image processing artifacts if they are present in a strip that is overlapped significantly by another image in the mosaic. Clouds commonly are present near the rims of canyons, but may occur anywhere. Large topographic variations (e.g., near chasmata) have correlated atmospheric dust opacity variations that are sufficient to produce color variations in the DCS image. Plateau vs. canyon floor comparisons should be avoided; differences between locations on the valley floors (or plateaus) probably are valid if their elevations are within 500 – 1000m. Images crossing large topographic boundaries require further correction [e.g., 4] for the most robust evaluation of mineralogical diversity.

Examples of Mineralogical Diversity: Materials that appear pink/magenta in the DCS images are quite common, and typically are mafic/basaltic (commonly olivine-rich) and/or dust-free relative to their surroundings. Examples include: Argyre, Holden crater, Iani Chaos, Isidis, Margaritifer, Mawrth Valles, N. Meridiani, N.E. Syrtis, Nili Fossae (trough and crater), S.W. Arabia, Terby crater, W. Candor Chasm, W. Meridiani, Becquerel crater, E. Melas, Eberswalde delta (Fig. 1), Eos Chasma, Gale crater (Fig. 2), and Hale crater.

Another color class of surfaces in the DCS images appear blue. There are two subclasses of blue-colored units, one with low inertia (e.g., Fig. 2) [5], and one with relatively high inertia (e.g., Fig. 3). Correlation with other datasets (e.g., nighttime temperature, inertia) can help determine the origin of color differences. The low inertia materials likely represent dusty surfaces [6], whereas the higher inertia units likely represent materials with discernably different compositions.

Summary: The above examples are only a sampling of the mineralogical variability observable in these DCS mosaics. In many cases, DCS mosaics of candidate MSL landing sites exhibit regional spectral diversity indicative of variable mineralogy. We are compiling a database of the color variations in each mosaic for further study.

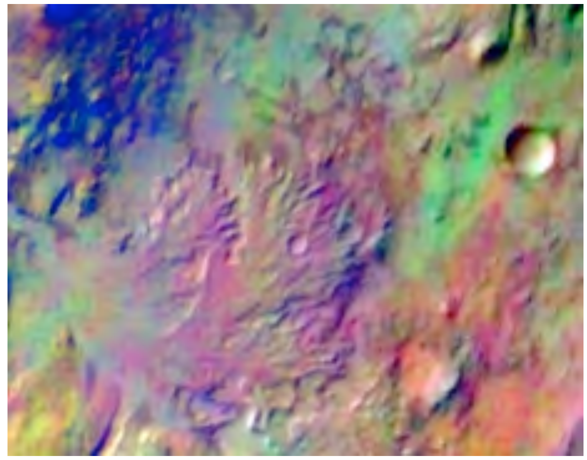

Figure 1. Eberswalde delta - basaltic (possibly olivine-bearing) composition in magenta.

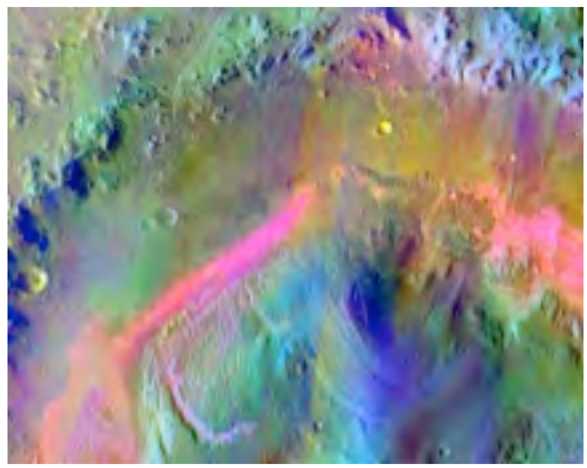

Figure 2. Gale crater - relatively low inertia (dusty) surface in blue (vs. basaltic/olivine-bearing in pink).

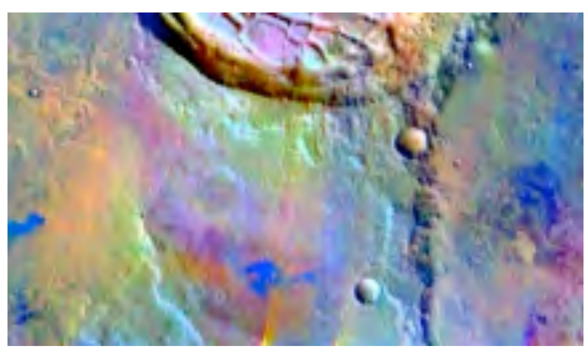

Figure 3. W. Meridiani – relatively high inertia (rocky) surfaces in blue. These likely are compositional variations.

References: [1] Christensen, P. R. et al. (2004) *SSR, 110*, 85-130. [2] Gillespie, A. R. et al. (1986) *Rem. Sens. Env., 20*, 209-235. [3] Bandfield, J. L. et al. (2004) JGR, 109, doi:10.1029/2004-JE002289. [4] Anderson, F. S. and Hamilton, V. E. (2005) *Eos Trans. AGU, 86*, Abstract #P24A-05. [5] Fergason, R. L. et al. (in press) JGR. [6] Pelkey, S. M. et al. (2004) *Icarus, 167*, 244-270.