STUDY OF TERRESTRIAL TERRAINS ANALOGOUS TO MARTIAN LAYERED, MASSIVE, AND THIN-BEDDED MATERIALS.

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High-resolution (2-5 m/pixel) images from the Mars Orbiter Camera (MOC) have generated new views of possible widespread, layered sediments, some as thick as 4 kilometers, at near-equatorial latitudes, now known as the layered, massive, and thin-bedded (LMT) materials [1]. Outcrops of this material showing layered bedding have led to the suggestion that the LMT unit may be lacustrine [1]. Alternatively, the LMT materials have also been suggested to be widespread "tephra" or volcanic ash deposits [2, 3]. Study of the layered material is important as its origin is contentious, it contains concentrated crystalline hematite deposits, which may be related to bacterial deposition [2, 4], and one layered hematite site is a prime candidate for a future landed mission on Mars.

In January of 2004, NASA's goal is to place on Mars two landers equipped with Mars Exploration Rovers (MERs); one is slated to land on a hematite/LMT site. The objective of the MER missions is to learn more about the ancient climate and putative water-rich environments through direct rock examination. Missions to Mars are expensive and it is necessary to be certain our Mars rovers can detect the origin of layered sedimentary terrains like the LMT units before they are deployed on that planet. Therefore, this study seeks to develop criteria to better identify the nature of these layered deposits from surface measurements and orbiting spacecraft data.

The Martian hematite/LMT units are visually similar to both terrestrial lacustrine and ash deposits. Both types of deposits can have variable brightness, are fine-grained, layered, massive, or thin bedded, and can erode with gullied (or badland) topography similar to the Martian material. In order to test the hypotheses of lacustrine vs. volcanic ash origin for the hematite/LMT deposits on Mars, we are studying terrestrial analog rocks in order to determine characteristics that (1) can be detected by instruments on surface rovers and spacecraft and (2) provide evidence for their origin. We have identified four terrestrial rock analogs, in areas that are relatively vegetation free, that have variable albedo, are fine-grained, layered, massive, or thin bedded, and erode in a fashion similar to LMT units. These rocks include fluvio-lacustrine and ash deposits within the Triassic Painted Desert and Blue Mesa Members of the Petrified Formation of the Chinle Group in northeast Arizona; and two Recent ash deposit sites from Hekla volcano and Veidivötn volcanic in Iceland. Each analog site was geologically evaluated using sedimentary structures and rock identification to interpret the environment and processes of origin. In addition, we will evaluate each site to (1) establish criteria that might be identified from space, (2) simulate visual data return of site characteristics, (3) simulate site soil characteristics of the rover wheel and trench tool disruption pattern, and (4) determine rock compositions.

Study Design. Each analog site has a simulated landing site and traverse within a 30x30 meter grid. To establish criteria that might be identified from space, we obtained local topographic maps and aerial photography at low "Viking-like" resolution (purchased from aerial photography vendors) and at high-scale "MGS-like" resolution (air photos from overflights) for each site. Our chosen grid for each site was located on these topographic and image bases. A survey tripod station was set up on the corner of this grid and a GPS reading was taken to locate the sites accurately.

To simulate visual data return of site characteristics, we will establish for each 30x30 meter grid a detailed topographic reference map using surveying data taken at 5 meter intervals. Digital images of the site characteristics and rock types will be draped over a digital elevation model (DEM) derived from the topographic map to create simulated lander and rover 3D PanCam views.

To simulate site soil characteristics of the rover wheel and trench tool disruption pattern, we planned to measure at each site the surface roughness using a manual hand held tool, as well as geophysical instruments (such as a penetrometer). These instruments could provide information about soil properties such as bearing strength, penetration resistance, and porosity. However, it was rapidly learned that these types of measurements were not performable on recent, unconsolidated ash. Without comparative data from all sites, the soil characteristic tests were eliminated.

To determine terrain compositions that simulate rover and return-sample analysis, two samples were taken at each sampling site along a simulated "rover traverse." One of these samples will be examined by petrographic (microscopic examination of thin sections), SEM (scanning electron microscope), XRD (x-ray diffractometer), spectral, and chemical means. Sieve analysis will determine size distribution. Samples will be sent away for probe perfect coverless mounts (thin sections that can be viewed using a microscope and then probed by SEM methods). Petrographic analyses and point counts of the thin sections, as well as X,Y mapping of thin-section minerals will be conducted for truth testing. SEM chemical and visual identification will be used. For organic molecule detection of carbonate and hydrogen, a private lab would analyze a portion of the samples. The other sample was acquired to correlate the lab analyses with rover instrument return. This set of samples will be sent for examination using simulated rover proto-type instruments. These analyses include optical microscopy, microprobe analyses for individual mineral phases, and x-ray diffraction. Finally, samples will likely undergo spectral analysis in the TES lab at ASU.

Preliminary Results. Our future work will contain the results from analysis and testing. The analog study is still in progress, however, initial field insights from the Veidivötn area in Iceland suggest that the appearance of horizontal and concentric bands of layers is not a definitive characteristic for lacustrine origin, and thus the possibility of a volcanic origin for the LMT deposits remains open. We note that layers within ash beds can be created by subsequent explosions, changes in particle size, composition, or degrees of welding. In addition, differential drying of beds produced in one eruption can form layers. We observed and collected bright-albedo banded volcanic clasts at the Veidivötn site indicating that volcanic eruptions can introduce rounded volcanic rocks from distal locales that show internal layering, similar to sedimentary rocks. The composition of these rocks could not be deduced by hand examination in the field or image data. Therefore, we suggest that on Mars, vesicle-free, fine-grained, layered, volcanic rocks will require compositional analysis to determine origin. Deposition and alteration of Mars ash similar to Fe-oxide rich tachylite tephra at this Icelandic analog site could provide a mechanism to generate hematite deposits on Earth. Finally, welding or devitrification of ash could have cemented the Martian materials in place and therefore provide a mechanism that preserved the hematite deposit from wind erosion.

References: [1] Malin M. C. and K. S. Edgett (2000) *Science 290*, 1927-1937; [2] Chapman, M.G. and K.L. Tanaka (2002) *Icarus 155*, 324-339; [3] Hynek, B. M. et al. (2002) *JGR 107*, in press; [4] Allen, C. C. et al. (2001) *Astrobiology 1,* 111-123.