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CHARACTERIZATION OF TERRAIN IN THE MARS SURVEYOR 2001 LANDING SITE LATITUDE AND ELEVATION REGION USING MAPPING PHASE MARS GLOBAL SURVEYOR MOC IMAGES.

M. C. Malin[1], K. S. Edgett[1], and T. J. Parker[2]. [1]Malin Space Science Systems, P.O. Box 910148, San Diego, CA 92191-0148. [2]Jet Propulsion Laboratory, M/S 183-501, 4800 Oak Grove Dr., Pasadena, CA 91109.

Introduction

One of the original objectives of the Mars Orbiter Camera (MOC), as proposed in 1985, was to acquire observations to be used in assessing future spacecraft landing sites. Images obtained by the Mars Global Surveyor MOC since March 1999 provide the highest resolution views (1.5–4.5 m/pixel) of the planet ever seen. We have been examining these new data to develop a general view of what Mars is like at meter-scale within the latitudes and elevations that are accessible to the Mars Surveyor 2001 lander. Our goal is to provide guidance to the 2001 landing site selection process, rather than to use MOC images to recommend a specific landing site.

Data

The data used in this study were acquired March–May 1999. We examined ~130 MOC images that occur between 5°N and 15°S and at elevations lower than the 2.5 km contour in the pre-MGS USGS topographic maps. Only images that showed obvious kilometer-scale hazards, such as the steep slopes in chaotic terrain and the walls of Valles Marineris were excluded from the study.

Background

Over the entire course of the MOC mission thus far, we have learned four important lessons about Mars at the meter-scale:

(1) Most of the martian surface is unlike what might be expected on the basis of photos from Viking and other previous orbiting spacecraft. Many meter-scale surface features defy explanation on the basis of terrestrial analogs and field experience.

(2) Most surfaces on Mars, including many that occur within the elevation and latitude constraints of the 2001 lander, do not resemble the Viking and Mars Pathfinder landing sites.

(3) Surface properties interpreted from remote sensing (*e.g.*, albedo, thermal inertia, rock abundance, radar reflectance) do not necessarily match what is seen in MOC images. For example, a portion of Daedalia Planum appears to consist of patchy, windblown sand and bare exposures of rock (lava flows), despite having an extremely low Viking IRTM-derived rock abundance and thermal inertia (which previously implied the presence of a thick mantle of dust). Another important observation is that some of the large, low albedo regions of Mars (*e.g.,* Sinus Sabaeus) are covered by indurated, dark mantles, not sand. Large (*i.e.*, > 1 km^2) outcrops of bare rock are also seen on the planet.

(4) Interpretation of meter-scale features visible in MOC images can typically be extended to textures and patterns on the surrounding terrain, even when the surroundings are only seen in lower resolution images. For example, a surface covered by small, meter-scale yardangs in a MOC image might appear as a dark patch in a Viking image (owing to shadows cast between yardang ridges). The meter-scale aspect of nearby dark patches in the Viking image can be inferred to be similar. This predictive capability has served well as a model for selecting targets for new MOC images and it is the key to using earlier mission data (*e.g.,* Viking, Mariner 9) to assess proposed sites for the 2001 lander.

Results

We have identified three general “rules” that can be used to provide a ~70% predictive capability with respect to interpreting the nature of potential landing sites. This percentage improves if one considers exceptions that group geographically. These “rules” can be applied to any Viking orbiter image up to about 300 m/pixel that occurs within the latitude and elevation range accessible to the 2001 lander.

General Rules

(1) Surfaces that are topographically rugged (“hummocky”) in Viking orbiter images (over 10s–1000s of meter scale) are smooth at meter-scale. Some of the best examples of surfaces of this type (within the latitudes 5°N–15°S) occur in the cratered terrains of the Amenthes/Nepenthes regions. The meter-scale character is dictated typically by the upper surfaces of mantle deposits that appear to drape all but the steepest topography. The mantles often appear to be indurated, as indicated by the crisp nature of features associated with superposed impact craters and/or occasional narrow cracks in the surface. However, we do not know if the induration is merely a thin crust, or if the entire deposit is solid (*i.e.,* we cannot estimate the weight-bearing strength of this material). Based on the absence of meter-scale boulders, we suspect that few rocks are present on these surfaces, but patches of what appears to be bedrock can commonly be found on non-mantled surfaces.

(2) Surfaces that are smooth in Viking orbiter images (10s–1000s of meter scales) are extremely rough at meter scales. This roughness is commonly expressed in the form of ridges and grooves spaced a few meters

(or less) apart. Some of the ridged surfaces are clearly the result of eolian erosion (*i.e.*, they are yardangs). However, many other surfaces are grooved, ridged, or pitted, but show no obvious features that would indicate their origin. Such surfaces are new to us and have only been clearly observed in the latest (1999) MOC images. The best examples of ridged and grooved terrain occur on the mare-like surfaces in the Amenthes Rupes region, the surface in Terra Meridiani identified by the MGS TES team to have a hematite signature, and the floor of Melas Chasma.

(3) It is rare to find a surface that is texturally homogeneous at the kilometer scale. Most MOC images taken in recent months cover areas that are 1.5 to 3 km wide by 3 to 12 km long. Within any one of these images (in the latitude and elevation range accessible to the 2001 lander), we find that most of the surfaces show a range of meter-scale morphologies.

Exceptions

Some geographical locations have specific landform relationships that, while exceptions to "rules" 1 and 2, are equally predictable. In particular, these regions are:

(1) The Medusae Fossae Formation (MFF) and immediately adjacent highland surfaces. These surfaces generally exhibit yardangs all the way down to the meter scale, although there are a few smooth surfaces at the very top of major MFF units in south Amazonis Planitia. The highlands adjacent to the MFF in the Memnonia region exhibit so many small yardangs that older landforms (*e.g.,* Mangala Valles fluvial features) can be completely obscured.

(2) The lowland known as the Elysium Basin (north of Apollinaris Patera, south of the Elysium volcanic rise) exhibits several exceptions to the "rules". Surfaces that appear to be dark and smooth in the ~230 m/pixel Viking images that cover most of this region appear to be quite rough at the meter scale. These rough surfaces include "platey" and flow-like textures. However, nearby bright surfaces that also appear to be smooth in Viking images are found to usually be smooth at the meter scale in MOC images.

Most exceptions involve surfaces that are smooth at both Viking and MOC image scales. However, we have seen very few exceptions. These, too, occur in specific geographic locations (and include the bright, smooth surfaces in Elysium Basin noted above):

(1) The bright feature located west of Schiaparelli Basin (generally centered at 6°S, 349°W). This surface appears to be relatively smooth and flat in Viking images. In MOC images, the surface appears to be somewhat etched, with about 15–20% pits and craters of 100s of meters diameter. However, the surface is otherwise smooth and boulder-free, and has the appearance of being hard (like rock). Other bright, smooth (and not pitted) surfaces occur in rather limited patches to the north of this area and in south Schiaparelli Basin.

(2) Relatively smooth, flat, dark surfaces occur in some parts of the Sinus Meridiani low albedo region. These surfaces do not correlate with the crystalline hematite observed by the MGS TES, but often occur along the margins of the hematite-bearing surface. Terrains further south of these are rough at Viking scales (*i.e.*, typical martian cratered highlands) and follow "Rule #1" by being relatively smooth at the meter scale. Similar smooth, dark surfaces occur in Sinus Sabaeus and on the southern floor of the Schiaparelli Basin (although most of these areas probably lie outside the elevation range of the 2001 lander).

(3) A smooth dark surface also occurs on the floor of Ganges Chasma. This surface is a thick, eolian sand sheet. A similar deposit might occur on the floor of Juventae Chasma.

Discussion

In the context of landing site selection, it is comforting to know that there are surfaces that do not appear to pose many meter-scale hazards. However, these types of surfaces tend to be the exceptions—the surfaces that appear to be smooth and flat at both Viking and MOC image scales. With the exception of the Ganges site, these smooth, flat surfaces would not likely present interesting vistas (*e.g.,* horizon features such as hills or cliffs) for the lander to "see". In addition, and again except for the Ganges sand sheet, the processes that formed the smooth bright and dark surfaces are not known. Likewise, the processes that made most surfaces that appear smooth at Viking scales to appear rough at MOC scales are not known.

Additional Work

During June 1999, we will refine our observations and test the proposed predictive capability (by targeting new images). The ideas presented in this abstract should be viewed as a "work-in-progress." By early July we plan to submit a report to the Mars Surveyor 2001 Project that details and illustrates our findings.

Conclusions

MOC images provide new and often unexpected information about the surface of Mars at the meter scale. What is seen in a MOC image can be easily extrapolated to the terrain seen in Viking images. In fact, "rules" presented here can be used to predict the nature of the meter-scale surface in places (within the 2001 lander elevation/latitude constraints) where MOC images are unavailable.