ROUGH IS SMOOTH AND SMOOTH IS ROUGH: THE MARTIAN SURFACE AT METER VERSUS HECTOMETER SCALES AND IMPLICATIONS FOR FUTURE LANDING SITES. M. C. Malin and K. S. Edgett, Malin Space Science Systems, P.O. Box 910148, San Diego, CA 92191-0148, USA.

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 provide the highest resolution views (1.4–4.5 m/pixel) of the planet ever seen. From these data we have developed a general view of what Mars is like at meter-scale and how surface textures and morphologies may impact Mars Surveyor lander objectives and programs. Our goal here is to provide guidance to the landing site selection process (and perhaps lander design), rather than to recommend specific landing sites.

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 surface is unlike what might be expected on the basis of photos from previous spacecraft. Many meter-scale surface features defy explanation on the basis of terrestrial analogs and field experience. (2) Most surfaces do not resemble the Viking and Mars Pathfinder landing sites. (3) Surface properties interpreted from remote sensing (*e.g.*, thermal inertia, rock abundance, radar reflectance) do not necessarily match what is seen in MOC images. (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. This last point allows for a predictive capability that has served well in selecting targets for new MOC images and it is the key to using earlier mission data (Viking, Mariner 9) to assess future proposed landing sites.

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 approaches 100% if one considers exceptions that group geographically. These "rules" can be applied to any Viking orbiter image up to about 300 m/pixel within the latitude and elevation range accessible to proposed/planned Mars Surveyor landers.

General Rules: (1) Surfaces that are topographically rugged in Viking orbiter images (over 10s–1000s of meter scale) are smooth at meter-scale. A good example occurs in the cratered terrain of the Amenthes-Nepenthes region, as illustrated in Figure 1a, 1b. The meter-scale character is dictated 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 as ridges and grooves spaced a few meters (or less) apart (*e.g.,* Figure 1c, 1d). Some of the ridged surfaces are clearly the result of eolian erosion (*i.e.,* yardangs). However, many other surfaces are grooved, ridged, or pitted, but show no obvious features that would indicate their origin. (3) It is rare to find a surface that is texturally homogeneous at the kilometer scale. Most MOC images cover areas that are 1.5 to 3 km wide by 3 to 12 km long. Within any one of these images 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 include: (1) The Medusae Fossae Formation (MFF) and adjacent highland surfaces. These areas 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. 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) A few of the brighter areas along the south margin of the lowland Elysium Basin appear to be smooth in both Viking and MOC images. (3) The bright feature located west of Schiaparelli Basin (generally around 6°S, 349°W). This surface appears to be relatively smooth and flat in Viking images. In MOC images, the surface is 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. (4) Relatively smooth, flat, dark surfaces occur in some parts of the Sinus Meridiani low albedo region. Similar surfaces occur in Sinus Sabaeus and on the south floor of Schiaparelli Basin. (5) Sand sheets. The largest example is found in Ganges Chasma and is smooth at both MOC and Viking (and Mariner 9) scales.

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 smooth, flat surfaces tend to be uncommon. With the exception of the Ganges Chasma sand sheet, these smooth, flat surfaces would not likely present interesting vistas; nor would they provide ready access to geologic outcrops of high-priority interest for remote sensing or rover investigation. In addition, and again except for the Ganges sand sheet, the processes that formed the smooth, flat "exception" surfaces are not known. It is also not known whether areas that appear smooth in MOC images may harbor sub-pixel roughness elements large enough to damage or destroy a lander. Likewise, the processes that made most surfaces which appear smooth at Viking scales to appear rough at MOC scales are not entirely known or understood at the present time.

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, the "rules" presented here can be used to predict the nature of the meter-scale surface in places where MOC images are unavailable.

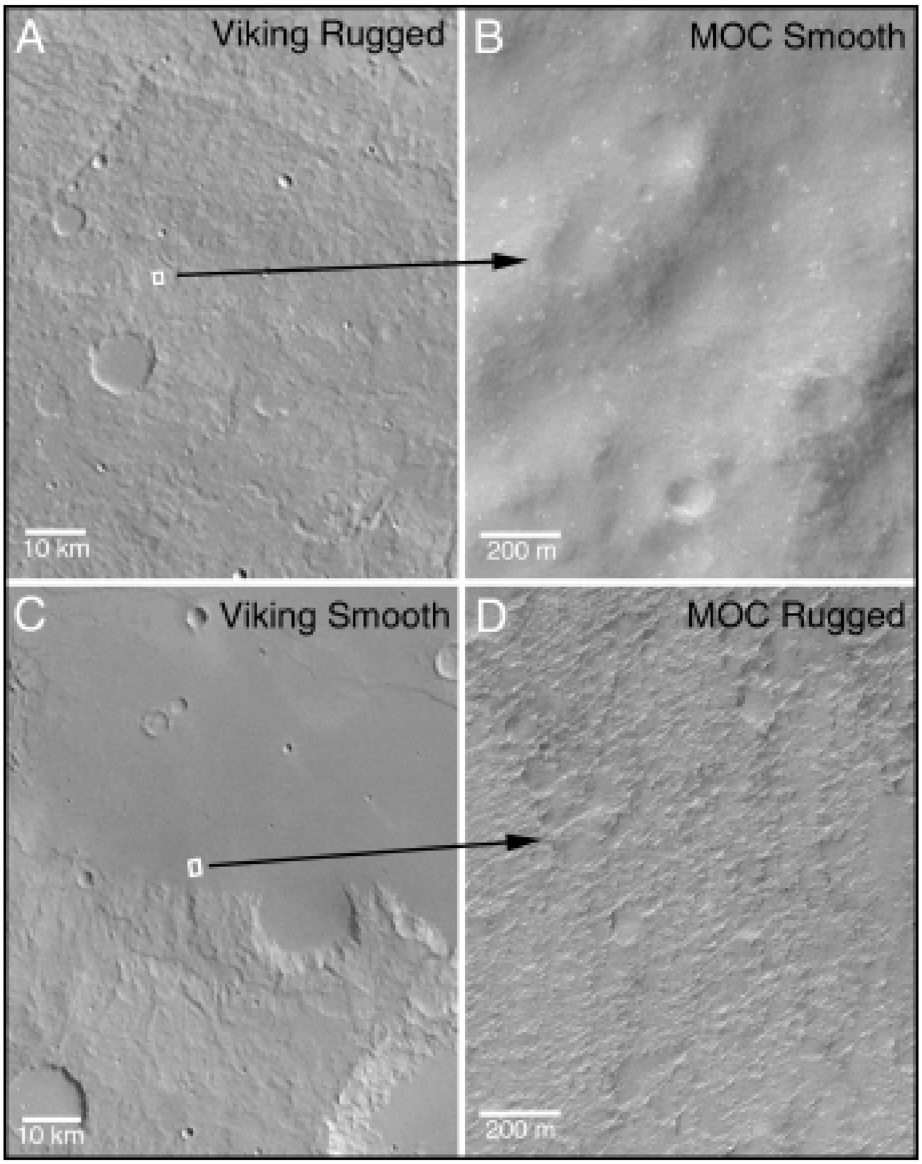

Figure 1. Terrain that appears rugged at Viking hectometer scales (A) appears smooth at the meter scale (B), while terrain that appears smooth at hectometer scales (C) looks rough at the meter scale (D). (A) Portion of a mosaic of Viking orbiter images 381S31–46; box shows location of (B), MOC image M00-01454 in the Nepenthes region near 5.3°N, 241.0°W. (C) Subframe of Viking orbiter image 379S44; box shows location of (D), MOC image M00-01619 in the Amenthes region near 1.1°S, 252.3°W.