THE SURFACE ROUGHNESS OF TERRAINS ON MARS. K. S. Deal[1], R. E. Arvidson[1], and G. A. Neumann[2], [1]Dept. of Earth and Planetary Sciences, Washington University, Campus Box 1169, One Brookings Drive, St. Louis, MO 63130 (deal@levee.wustl.edu), [2]Dept. of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology; Laboratory of Terrestrial Physics, NASA GSFC.

Introduction: The RMS roughness measurements produced by *Neumann et al.* [1] from Mars Orbiter Laser Altimeter (MOLA) data provide unique information about surface height variations at an effective length scale of < 75 m. Roughness at this scale is important not only for landing site safety considerations, but also for assessment of landscape evolution, which depends on emplacement mechanisms and erosional/depositional processes.

Here we present an examination of the global surface roughness map with discussion of terrain types and potential formation and/or alteration mechanisms. Spatially coherent terrain types were identified based on inspection of the roughness map. These terrains were further characterized through analysis of morphology and geology using MOLA topography, MOC wide-angle, and MOC narrow-angle images as well as the geologic maps produced by *Scott & Tanaka* and *Greeley & Guest* [2,3]. All of these data were used to explore potential formation and modification processes.

Roughness Controls: The roughness of a terrain at any length scale is controlled both by formation and subsequent modification processes and events. For example, emplacement of volcanic flows tends to smooth terrains over long length scales (100's meters to kilometers) and may produce rough surfaces at finer scales due to formation of flow surface textures (e.g., a'a lava), flow fronts, pressure ridges, cones, and related features. Volcaniclastic processes tend to smooth surfaces at all scales. Impact cratering produces landforms that can be both rougher and smoother than pre-existing terrains. Tectonic processes tend to roughen surfaces, but mass movement on resultant slopes can be a diffusional process that smooths tectonically controlled terrains. Erosion by wind and water is intrinsically a roughening process whereas deposition in association with these fluids tends to smooth surfaces. Likewise, periglacial and glacial processes produce landforms that can be either rougher or smoother than pre-existing surfaces, depending on the nature of the materials and whether erosional or depositional modes produced the features. The objective of the current work is to delineate the relationships between roughness and landforms, with an emphasis towards understanding emplacement and modification processes.

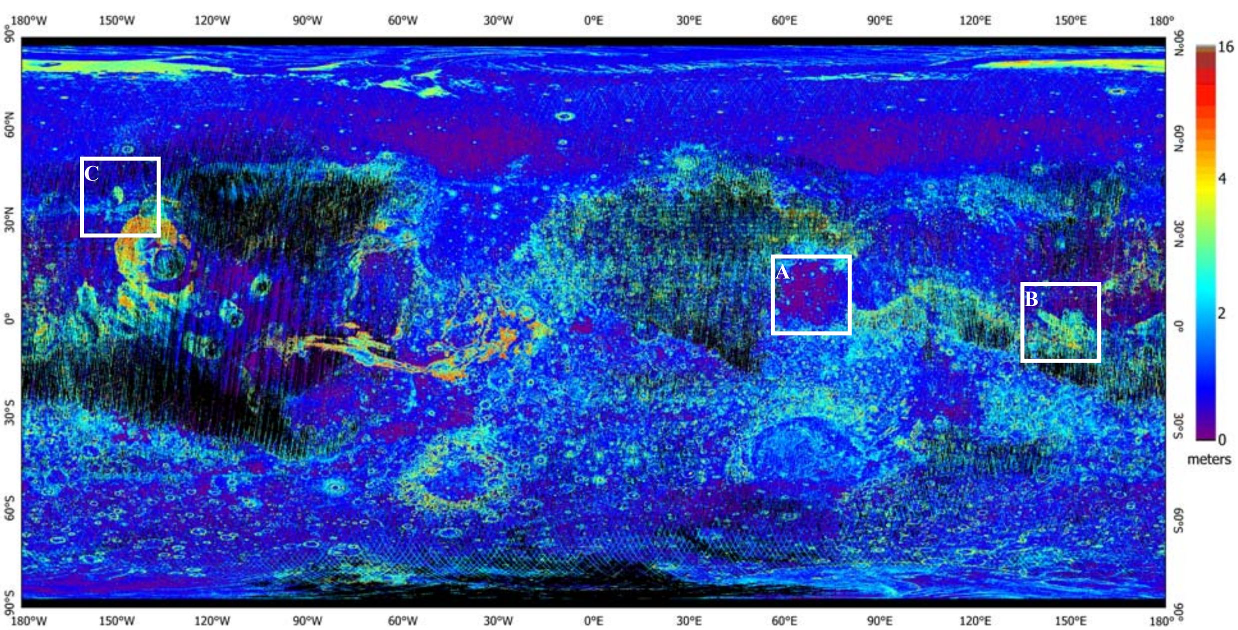

Figure 1. Global surface roughness map of Mars. A square root color stretch was applied; warm colors indicate high roughness values while cool colors are low. Blackened areas have no valid data. The white boxes correspond to context image locations for Figures 2.

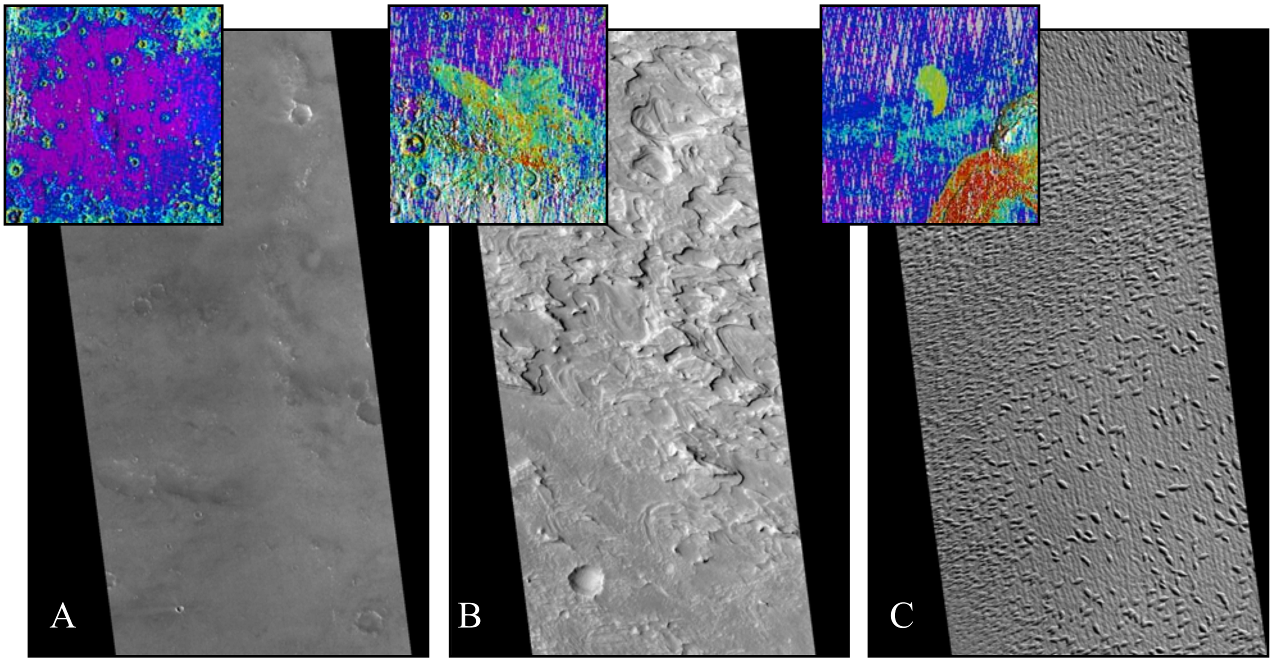

Figure 2. Example terrains of various roughness and landscape morphology. Context images (locations indicated in Figure 1) are roughness values overlain on MOLA-derived shaded relief. **(A)** MOC NA image M0801865 showing smooth dark terrain in Syrtis Planum, **(B)** MOC NA image M0202978 showing differentially eroded layered deposits in the Medusa Fossae Formation, and **(C)** MOC NA image M1000770 showing both individual and merged elongate pit structures from the teardrop-shaped terrain in southeast Arcadia Planitia. Illumination is from the lower left in this image.

Terrain Types: The global distribution of surface roughness is illustrated in Figure 1. The most noticeable features are intuitive: crater rims and ejecta, rocky canyon walls in Valles Marineris, and the dissected Olympus Mons aureole are rough, whereas northern plains deposits, large basin interiors, and extensive volcanic flow fields such as those found in Syrtis Planum are relatively smooth. As an example of a volcanic depositional regime, the Hesperian-aged lava flows in Syrtis Planum typically exhibits RMS roughness values below the 1-meter detection limit (Figure 2A). Small crater rims and caldera walls of Nili and Meroe Patera are observed as rough circular features within this otherwise smooth and nearly featureless terrain.

Other terrains are slightly less well recognized for intrinsic roughness properties and are more complex in their formation and modification histories. For example, the Medusa Fossae Formation extending west of Tharsis along the crustal dichotomy boundary is characterized by several large lobate mounds of Amazonian-aged layered materials (Figure 2B). This formation is thought to be composed of thick accumulations of volcanic ash that was subjected to extensive aeolian erosion [2,3,4]. Consequently, the observed moderate to high surface roughness values may be attributed to both the friable nature of the original deposit as well as the differential erosion that has sculpted the formation to its present form.

Vastitas Borealis dune fields located in the high northern plains are also notable as terrains with enhanced RMS values (typically 2-5 m). High-resolution (512 pixel/degree) MOLA coverage is able to resolve lineated dunes with spacing up to 1 km, enhancing the observed roughness as regional slope effects were removed at the km-wavelength scale. In MOC narrow-angle coverage, individual dunes can be observed to overly subdued-appearing patterned ground.

Glacial or ground-ice interactions also affect surface roughness properties. The relatively small area located at approximately 40ºN, 150ºW in southeast Arcadia Planitia may be one example (Figure 2C). This teardrop-shaded area does not display a discernable topographic signature, was not previously identified as a distinct geologic unit, and cannot be discerned by thermal inertia or albedo from surrounding materials. Analysis of MOC narrow-angle images, however, reveal that this relatively rough terrain consists of multiple elongate pits which seem to merge together to produce the lineated or grooved landscape that is characteristic for the unit.

In summary, there are many landforms that show distinct RMS roughness signatures relative to surrounding areas and correspond to understood emplacement and/or modification processes. We are currently pursuing these correlations in more detail to understand the relationship from a morphologic and geologic perspective. In addition, we are examining evidence (from MOLA profiles and the RMS values) for unique fractal signatures that might be diagnostic of both formation and/or modification processes and roughness distributions at scales finer than the 75 m MOLA footprint.

References: [1] Neumann G. A. et al. (in press, 2003) *GRL*. [2] Scott D. H. and K. L. Tanaka (1986) USGS I-1802-C. [3] Greeley R. and J. E. Guest (1987) USGS I-1802-B. [4] Bradley B. A. and S. E. Sakimoto (2002) *JGR, 107,* 2.