GLOBAL ROUGHNESS TEXTURE OF THE MOON AND MARS P. L. Whelley[1], M. Rosenburg[2], L. S. Glaze[3], E. S. Calder[1], [1]Departments of Geology, University at Buffalo, SUNY, Buffalo, NY, pwhelley@buffalo.edu; [2]Devision of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA; [3]Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD

Introduction: Statistical measures of patterns (textures) in surface roughness are used to quantitatively differentiate regional geomorphic units on the Moon and Mars (e.g. cratered highlands, volcanic terrains and planar lowlands). The existence of vastly distinct crustal types on Mars and the Moon is well established [e.g. 1, 2, 3, & 4]. Here, a new methodology developed for differentiating terrestrial volcanic deposits using ~1 m resolution topography data [5], is tested on two global data sets where roughness pixels are much larger (1/4 of a degree).

Methods: For Mars, roughness on the ~5-m scale was derived from the pulse spreading of individual laser returns from the Mars Orbiter Laser Altimeter (MOLA, [6]). Lunar roughness was derived from Lunar Orbiter Laser Altimeter returns using along track differential slope [4] at the ~57-m (one shot spacing) scale. Eight co-occurrence texture statistics were then calculated, for both bodies as demonstrated in [7]. To calculate texture, quantized roughness values (n=64) are used to populate co-occurrence matrices. Texture features are then identified by computing the probability of the same (quantized) roughness level occurring in the same location in two search windows (base and shift) each 11 pixels square, the search window is offset δ pixels and θ degrees from the base window. Co-occurrence probability is defined by [7]:

$$\Pr(x) = \{C_{ij} \mid (\delta,\theta)\}$$

Where C_{ij} is the co-occurrence probability between roughness levels i and j as defined by [7]:

$$C_{ij} = \frac{P_{ij}}{\sum_{i,j=1}^{G} P_{ij}}$$

Where P_{ij} represents the number of co-occurrences of roughness levels (i and j) between the base and shift windows with a specified quantization level (G). The following statistics are then applied to the co-occurrence matrix to identify the roughness texture [7 & 8]:

Contrast: $$CON = \sum C_{ij}(i-j)^2$$

Entropy: $$ENT = \sum C_{ij} \log C_{ij}$$

Second Moment: $$SMT = \frac{\sum C_{ij}{}^2}{\sum C_{ij}}$$

Results: Patterns in composite (CON, ENT, SMT) roughness texture maps are apparent [Fig: 1&2]. Cratered highlands (for both bodies) have high ENT, meaning there is a lot of randomness in the roughness distribution and high CON from large differences in roughness over short spatial scales; this is likely a result of the random distribution of impact craters and the common juxtaposition of smooth crater floors and rough rims. The martian northern lowlands [Fig: 1] have high SMT indicating a homogeneous distribution of roughness elements; likely a result of the smooth relatively young surface and dearth of craters. Martian volcanoes: Tharsis, Elysium and Olympus Montes all have high CON & ENT on their edifices, but are surrounded with regions of high SMT. This may be a result of high relief volcanic features on their flanks able to show through a thick dust layer while more distal deposits are more subtle and therefore buried by dust. For martian volcanoes, Syrtis Major has anomalously high SMT. Some lunar mare have high SMT, indicating homogeneous roughness distribution, however impact craters within mare units commonly produce patches of high CON and ENT as well. While the mare and lunar highlands are compositionally distinct [e.g. 2 and ref. within], results here suggest they are far less texturally distinct at this scale. Perhaps this is due to eons of post-mare impact cratering without the smoothing of aeolian erosion and burial common on Mars.

Conclusions: This study demonstrates that roughness texture is well suited for differentiating geomorphic units on both bodies. Specifically it was found that 1) cratered highlands on both the Moon and Mars have high randomness and contrast in their roughness distributions; 2) martian northern planes (and notably less-so lunar mare) have generally homogeneous roughness distributions except where craters exist; and 3) large martian volcanoes have high contrast and are bound by highly homogeneous roughness units. Further work will focus where high-resolution elevation data exist and will attempt to differentiate local scale geomorphic units based on roughness texture. For example, impact crater ramparts, lava flows, dark mantle deposits and sand dunes are all expected to have unique roughness textures.

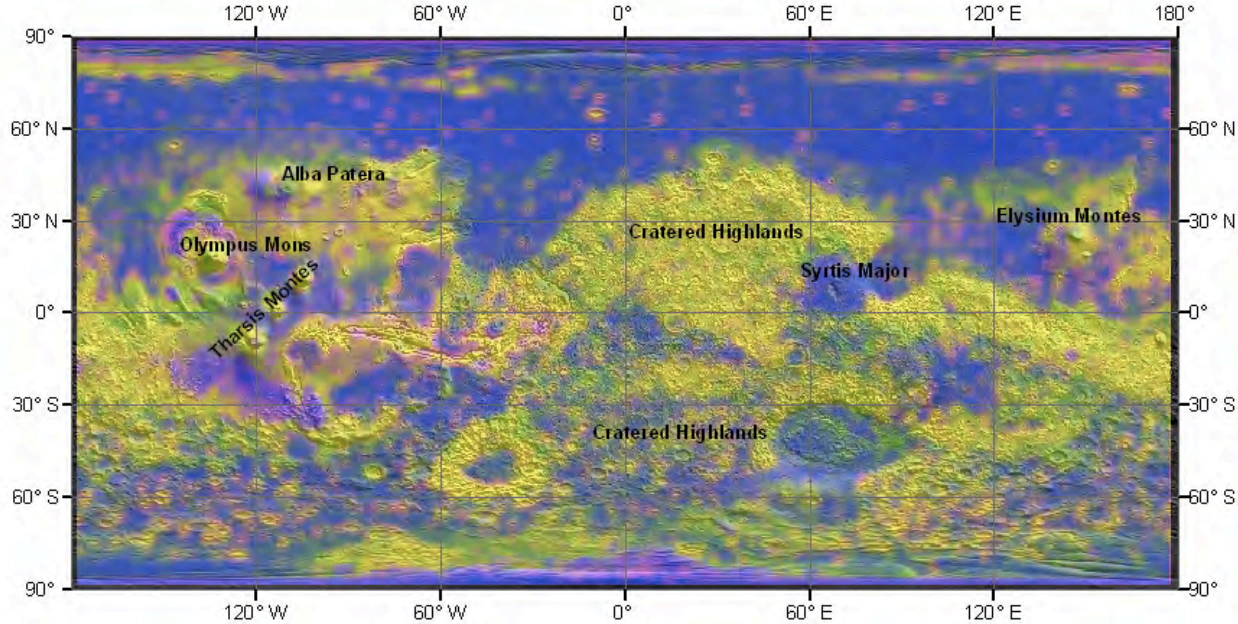

Figure 1: Mars (R:CON, G:ENT, B:SMT) roughness texture map at the ~5-meter scale draped over MOLA derived shaded relief. ¼ degree pixels are ~ 470 m pixels at the equator.

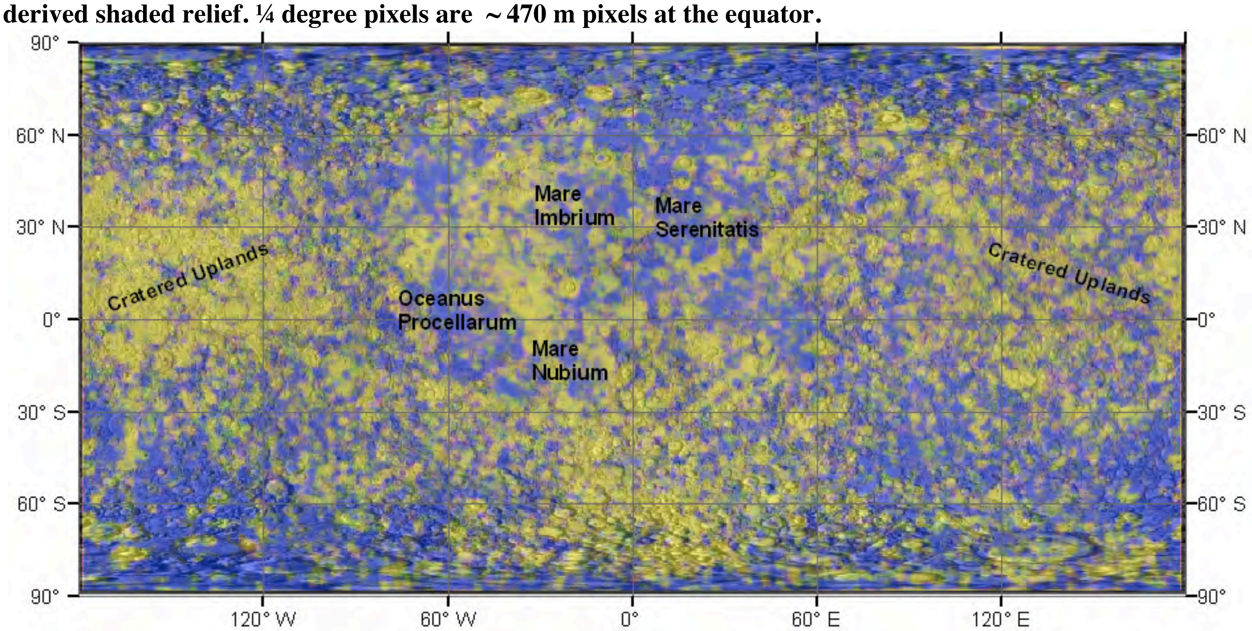

Figure 2: Moon: (R:CON, G:ENT, B:SMT) roughness texture map at the ~57-meter scale draped over ULCN2005 shaded relief (USGS). ¼ degree pixels are ~240 m at equator.

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