INVESTIGATING THE EFFECT OF MECHANICAL AND ELECTRICAL REGOLITH PROPERTIES ON GEOMORPHOLOGICAL SHAPE FORMATIONS. A. ElShafie[1], E. Heggy[2], J. C. Dixon[1,3], V.F. Chevrier[1], N. Dennis[4]. [1]Arkansas Center for Space and Planetary Sciences,[2]NASA Jet Propulsion Laboratory, [3]Department of Geosciences, [4]Department of Civil Engineering, University of Arkansas, Fayetteville, AR 72701. aelshafi@uark.edu

Introduction: Gullies, slopestreaks and landslides are all geomorphological features observed on the surface of Mars [1, 2]. Their trigging mechanism debated among the scientific community, however, their current form and stability depend on the mechanical properties of the regolith in which they are developed. High resolution cameras and radar, among other instruments, have been used on board different missions to observe these surface features [3 and 4]. Interpretation of the topographical images, inversions of radargrams and numerical modeling require knowledge of the mechanical properties of the surface and the subsurface such as density, porosity and friction angle. In this research, we simulated gully formation under different bulk densities with the objective of correlating mechanical and electrical properties of the regolith to gully shape which enhances our knowledge, analysis and interpretation of previous, current and future surface forms.

Experimental Methods: We conducted our gully experiments in a flume 1 x 0.8 x 0.15 m^3 which has the ability to be adjusted to the desired slope angle (Fig. 1). Different degrees of compaction were examined with a homogenous distribution layers, therefore, a specific sampler test structure was built (0.7 x 0.45 x 0.04 m^3) with a top movable plate (Fig.1). Before loading the regolith, the top movable plate is clamped to the lower test structure. Regolith is poured into the sampler and compacted to the desired density. Sliding the top movable plate took place to remove the excess of regolith and to fill the gaps. Once the sample is prepared, it is placed into the flume with the adjusted slope and connected to the water supply. Our experiments were carried out at slope of 10° and water flows of 10 GPH for 25 sec.

Direct shear tests were performed on JSC Mars-1 simulant in order to determine the angle of internal friction (ASTM D-3080). Different compaction levels were prepared and then subjected to predefined normal stress and the shear force was calculated. From these data, the angle of internal friction (φ) of the regolith samples was determined by a best fit linear regression.

Electrical measurements of the thin sliced samples < 3 mm in thickness were carried out at room temperature using a dielectric material test fixture attached to an Impedance/Material Analyzer. The analyzer is connected to a central command unit to extract data and calculate, in real-time, the real and imaginary part of the complex dielectric constant. Sweeping over the frequency range of observation, the real and imaginary parts of the relative complex permittivity were calculated. Values of relative permittivity were measured over the entire frequency range (10 MHz to 1 GHz).

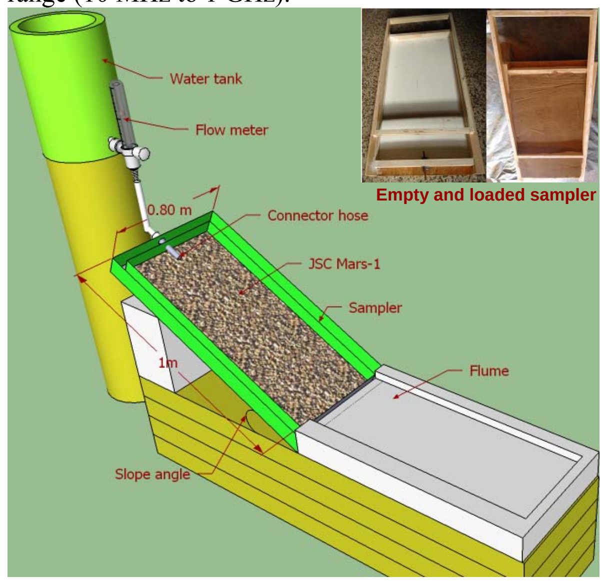

Figure 1. Gully simulation flume and test sampler.

Results: Gully Total Length (T.L) was affected by the density of the prepared samples. A linear increase in the formation length was observed as a function of different bulk densities (Fig. 2). Total length increased from about 25 cm at the lowest compaction level (~970 kg m^{-3}) to about 50 cm at the most compacted state (~1130 kg m^{-3}) for JSC Mars-1. The angle of internal friction of the regolith material was found to be function of the level of compaction which increased with increasing the bulk density. Friction angle varied from 39.4 to 54.7° at bulk density of 900 to 1120 kg m^{-3} for JSC Mars-1 (Fig. 3).

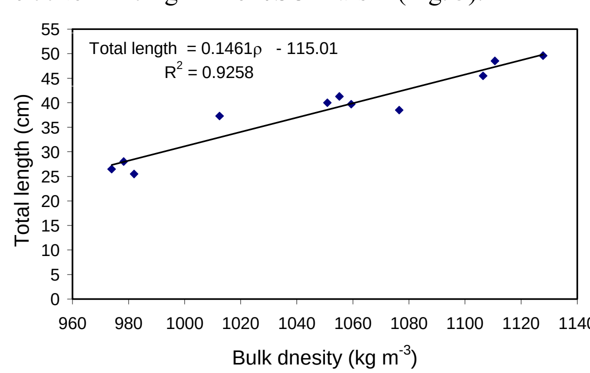

Figure 2. Total length as a function of different bulk density for JSC Mars-1.

Dielectric measurements of JSC Mars-1 were conducted in the frequency range (10 MHz to 1 GHz). Permittivity was found to decrease with increasing the frequency (Fig. 4) and to increase with increasing the density of regolith samples (Fig. 5). The dielectric constant increased from ~ 3 to ~ 8 from density of about 1200 kg m^{-3} to 1860 kg m^{-3}.

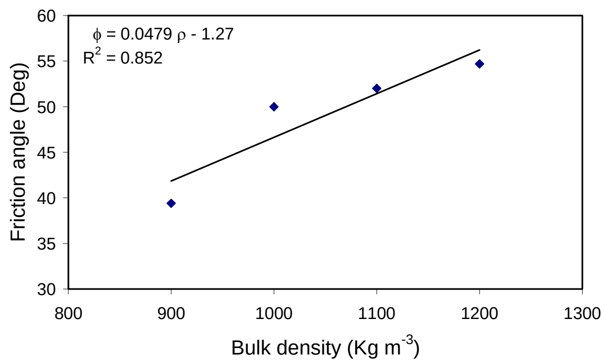

Figure 3. Friction angle as a function of different bulk density for JSC Mars-1.

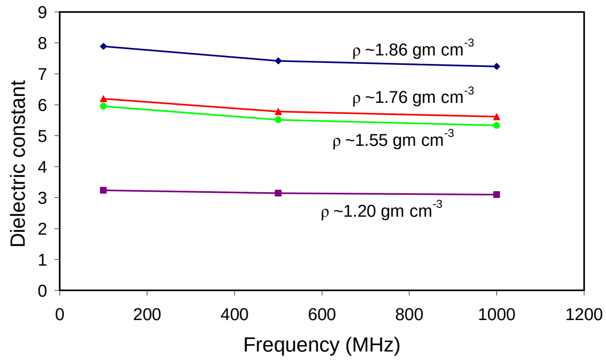

Figure 4. Dielectric constant of JSC Mars-1 as a function of measured frequency for different sample density.

Discussion: Gully total length was observed to increase with increasing the density of the regolith. Low density imply greater void ratios, therefore, there is more space for the water to flow in all possible ways which produces short formations. However, at high bulk density (low void ratio) water was forced to push against the regolith and form longer formations. Since friction angle and dielectric constant of the regolith was found to be function of the density of the prepared samples, we used their relations with bulk density to correlate with formation total length. We correlated between the calculated friction angle, dielectric constant and the formation total length (Fig. 6).

$$\phi = (0.3035 \times T.L) + 37.357$$

$$\varepsilon = (0.0374 \times T.L) + 0.8361$$

Gully total length has a linear increase with increasing the dielectric constant and friction angle of the regolith. However, the effect of scalling was not part of the investigation, these correlations can aid in the interpretation of the gully images or inversion of radargrams.

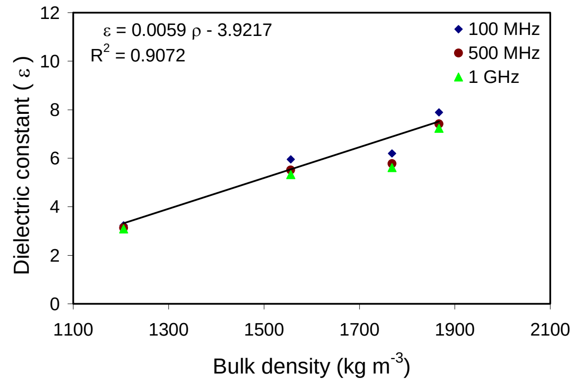

Figure 5. Dielectric constant of JSC Mars-1 as a function of different sample density over the frequency of 100, 500 MHz and 1 GHz.

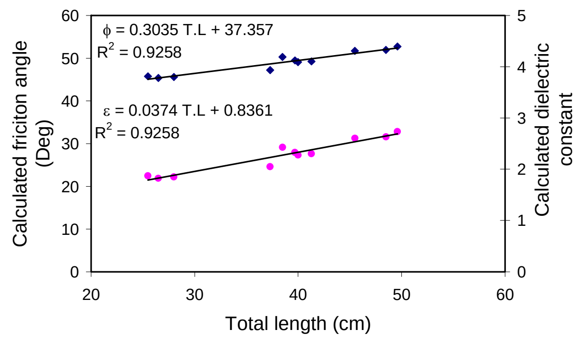

Figure 6. Calculated friction angle and dielectric constant as a function of total length for JSC Mars-1.

Conclusions: Gully total length, regolith dielectric constant and friction angle are found to be function of the density of the formation. An increase in the density would correspond to an increase in formation total length, friction angle and dielectric constant.

References: [1] Costard, F., et al. (2002) *Science*, *295*, 110-113. [2] Heldman, J. L., et al. (2007) *Icarus, 188,* 324-334. [3] Dundas, C. M., et al. (2010) *GRL*, *37*, L07202. [4] Picardi, G., et al. (2005) *Science, 310*, 1925-1928.