PRELIMINARY RESULTS OF A NEW TYPE OF SURFACE PROPERTY MEASUREMENT IDEAL FOR A FUTURE MARS ROVER MISSION. C.R. Buhler[1], C.I. Calle[2], J.G. Mantovani[3], M.G. Buehler[4], A.W. Nowicki[1] and M. Ritz[1]. [1]ASRC Aerospace, ASRC-15, Kennedy Space Center, FL 32899; [2]Electrostatics and Materials Physics Laboratory, NASA Kennedy Space Center, YA-C2-T, Kennedy Space Center, FL 32899; [3]Florida Institute of Technology, 150 West Boulevard, Melbourne, FL 32901; [4]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109.

Introduction: The success of the recent rover missions to Mars has stressed the importance of acquiring the maximum amount of geological information with the least amount of data possible. We have designed, tested and implemented special sensors mounted on a rover's wheel capable of detecting minute changes in surface topology thus eliminating the need for specially-made science platforms. These sensors, based on the previously designed, flight qualified Mars Environmental Compatibility Assessment (MECA) Electrometer, measure the static electricity (triboelectricity) generated between polymer materials and the Martian regolith during rover transverses. The sensors are capable of detecting physical changes in the soil that may not be detectable by other means, such as texture, size and moisture content. Although triboelectricity is a surface phenomenon, the weight of a rover will undoubtedly protrude the sensors below the dust covered layers, exposing underlying regolith whose properties may not be detectable through other means.

Prototype Design: The Wheel Electrometer Sensor (WES) consists of induction electrometers covered with insulator polymer materials similar to the MECA Electrometer. The polymers are chosen to span the triboelectric series which dictates how a material charges after contact with other materials within the series. Four polymer materials were chosen: Lexan (polycarbonate), Teflon (Polytetraflouroethylene or PTFE), Lucite (polymethylmethacrylate or PMMA) and Fiberglass (G10). A prototype WES was created to show that such sensors could generate a consistent charge after repeated contacts with soil materials and that changes in soil properties correspond with differences in the charging properties of the insulators. The prototype wheel is 12.7 cm in diameter and has a width of 10.3 cm. The four triboelectric sensors have diameters of 1.84 cm with a concentric guard and a shield which is capped with insulator disks of 2.0 cm in diameter and 0.7 cm thick.

The prototype WES is shown in Figure 1 rolling over JSC Mars-1 Martian regolith simulant [1]. The current design allows for the wheel to revolve about an axis of 20 inches in length. After three complete revolutions the wheel backtracks its steps to unwind the attached wires. Typical results are shown in Figure 2 for traverses over beach sand or SiO_2 at standard room conditions.

Figure 1. Prototype WES rolling over JSC Mars-1 Martian regolith simulant.

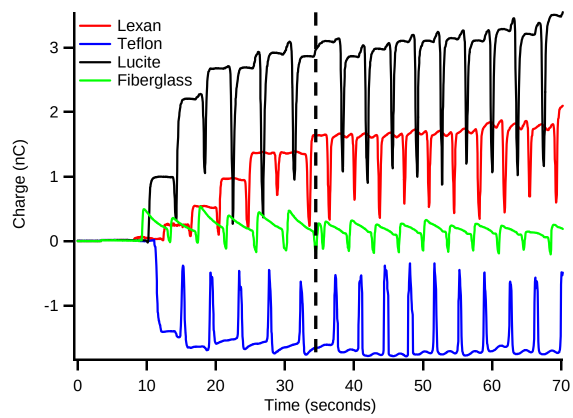

Figure 2. Typical charging of the WES over SiO_2 at room conditions 45% RH and 73°F. The dashed line represents where the wheel stopped and rotated in the other direction.

In Figure 2, only a few contacts with the material are required to provide consistent charging after which there is no additional charge exchanged. Second, each insulator charges differently depending on the material in contact. The spikes toward zero indicate points at which the sensors are in contact with the soil and only Fiberglass exhibits any charge decay over the wheel rotation time period. Finally, no cleaning or deionizing of the sensors was used here. This prevents the need for advanced mechanisms or additional chemicals required for cleaning sensors during planetary missions.

Preliminary Results: The initial tests highlighted WES's ability to detect certain characteristics of the Martian regolith. The first characteristic was mineral changes. Three materials JSC Mars-1 simulant, SiO_2, and limestone were each sieved to particles sizes between 280 µm and 500 µm. The average charging for Teflon is presented in Figure 3 for several runs.

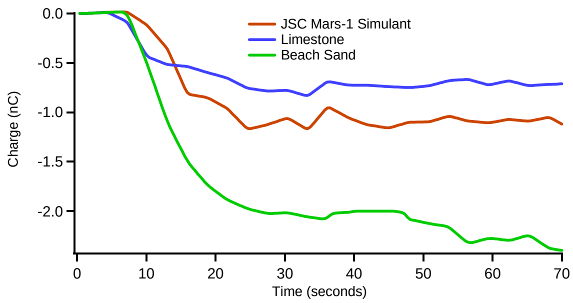

Figure 3. The average charging of Teflon for several runs (more than 75 contacts) for three soils, JSC Mars-1 simulant, Limestone and Beach Sand.

Teflon clearly charges higher for sand than it does for limestone and simulant. Simultaneously and equally important, the other sensors recorded very little charge differences as a function of mineral type. Although the triboelectric charging in Figure 3 is more likely a function of physical properties such as texture or hardness rather than of intrinsic mineral properties, the consistent and reproducible nature of this data indicates that it is possible to categorize this data as a sort of "triboelectric spectroscopy" for minerals. In fact, triboelectric properties of materials have been used to identify different plastics and polymers for the recycling industry for several years [2].

The next series of tests included studying the WES's performance as a function of particle size. Here the JSC Mars-1 Martian regolith simulant was sieved in three sizes: particles with diameter a > 500 µm, 280 µm < a < 500 µm, and 100 µm < a < 280 µm. The results are shown below in Figure 4 for Lucite.

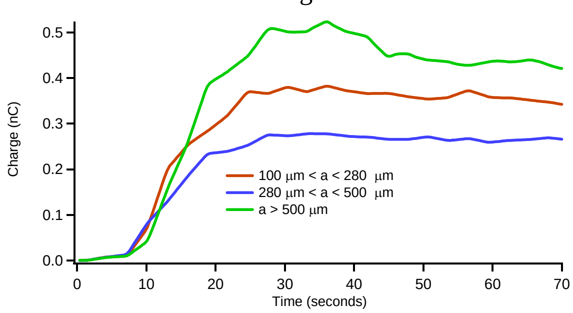

Figure 4. Tribocharging of Lucite as a function of JSC Mars-1 simulant of different sizes.

Lucite and Lexan exhibited similar charging behavior while Teflon charged very little for 100 µm < a < 280 µm and much higher for particles with diameters a > 280 µm. Fiberglass charged very little.

The WES can also detect underlying materials when covered with a fine dust layer. In the next series of experiments, the simulant was ground down below 5 µm and deposited onto limestone.

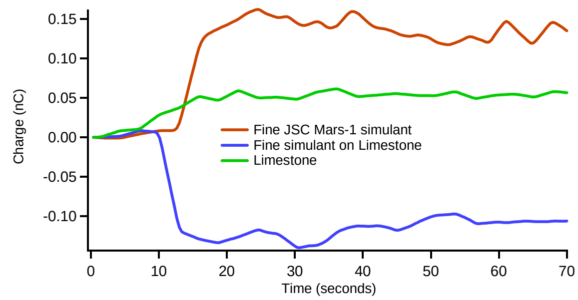

Figure 5. The average charging for Lexan for pure ground simulant, fine simulant on top of limestone and limestone lightly covered with simulant.

The average charge on Lexan shows a negative response for the dust covered mixture even though each material charges Lexan positive when unmixed. Fiberglass and Teflon detect only fine simulant and cannot distinguish between mix and pure, while Lucite charges between pure simulant and pure limestone.

Moisture is well known to effect the electrostatic properties of soil and this is reinforced by the results of regular, unsieved JSC Mars-1 simulant compared to simulant that has been baked out for several days in a moisture-free environment as in Figure 6.

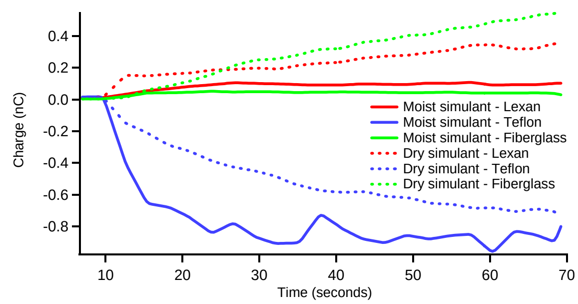

Figure 6. Differences in WES's response to moist/dry simulant for Lexan, Teflon and Fiberglass.

Lexan and Fiberglass tend to charge higher with lower moisture content while Teflon appears to charge lower. The results presented in this paper suggest that it is entirely possible to use the triboelectric properties of soils to detect changes in the physical properties of the surface during rover traverses.

References: [1] Allen, C., Jager, K., Morris, R., Lindstrom, D., Lindstrom, M., and Lockwood, J., "JSC Mars-1: A Martian Soil Simulant" *Proc. Conf. American Soc. Civil Engineers*, Albuquerque, 469-476 (1998). [2] see the Tribopen® at www.walkersystems.de/PID/tribopen/Paper.htm