MARS REGOLITH THERMAL AND ELECTRICAL PROPERTIES: INITIAL RESULTS OF THE PHOENIX THERMAL AND ELECTRICAL CONDUCTIVITY PROBE (TECP)

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Background: Phoenix was the first Martian lander to operate at polar latitudes, affording a unique opportunity to study the current climate, and the role of surface-atmosphere exchange. The Thermal and Electrical Conductivity Probe (TECP), a component of the Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) made the first-ever *in-situ* measurements of the thermal and electrical properties of the Martian regolith in a polar region that is key to Martian climatic evolution [1].

Based on the small, dual-probe sensors that are routinely used to monitor terrestrial soil thermal properties and water content, TECP performs 6 distinct measurements: dielectric permittivity, electrical conductivity, temperature, thermal conductivity, volumetric heat capacity, and relative humidity (Figure 1). The present abstract addresses regolith thermal and electrical properties; the results from the relative humidity measurements are discussed elsewhere [2].

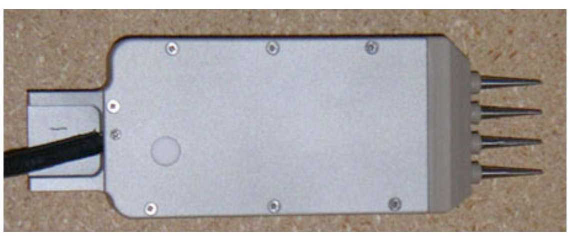

Figure 1. TECP Flight Unit.

Data & Analysis: Six distinct surface locations within the Phoenix workspace were probed via TECP throughout the course of the mission.. One site, named Vestri, was monitored several times through the first 70 sols, in each instance through a full diurnal cycle.

Measured regolith temperatures ranged from 253 K to 181 K (Figure 2). Shadowing by the Robotic Arm (RA), the Robotic Arm Camera, and scoop are evident around 1300h LMST.

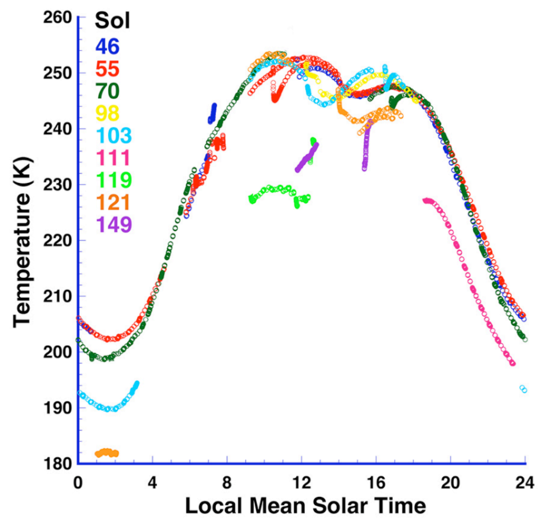

Figure 2. Regolith temperature as a function of LMST for all soil measurements.. Summer solstice (L_s = 90°) occurred on ~ sol 30.

The *in situ* thermal properties of the Martian regolith are determined via the transient heated needle technique. In this approach, a heat pulse is applied via a heater in one of the needles, and the thermal response of the medium is measured by tracking the temperature of the heated needle, as well as an adjacent needle. Material thermal properties are determined by fitting the time series temperature during heating and cooling to the theoretical response derived by Carlslaw and Jaeger [4]. See [1] for functional calibration details.

Thermal conductivity and volumetric heat capacity did not differ significantly in the six sites measured. However, a positive correlation of both properties was measured as a function of regolith temperature (Figure 3). At Mars surface temperatures, *C* is a strong function of temperature. In addition, the fact

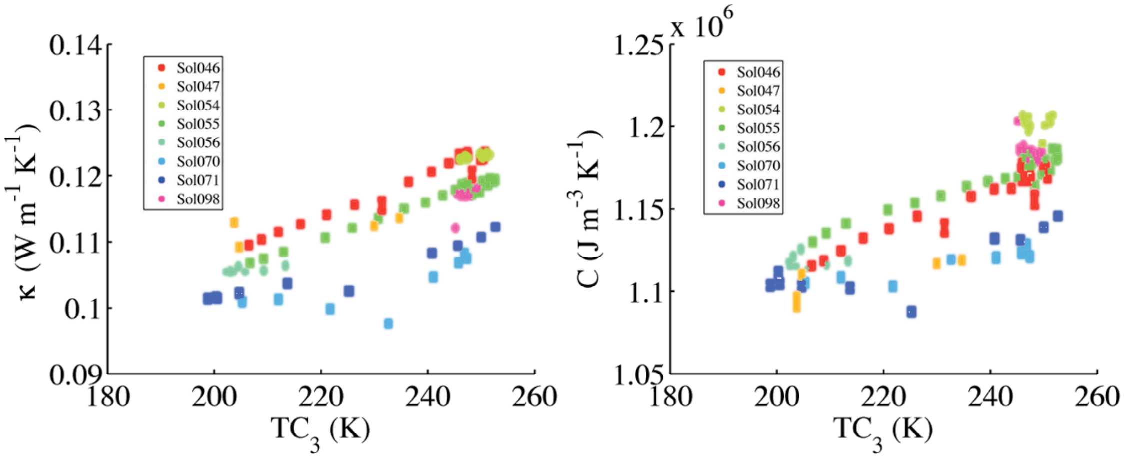

Figure 3. The thermal conductivity and volumetric heat capacity of the Martian regolith as determined by TECP.

that the thermal properties were measured in a non-isothermal medium can also contribute to the apparent hysteresis-like behavior of thermal conductivity. The thermal inertia derived from the measured properties is ~ 360 in SI units, somewhat higher that the values measured from orbit [5]. An observable halo around the lander, along with evidence of surface erosion at the site, suggests that the pre-existing regolith surface was strongly disturbed by the Phoenix landing.

Interpretation of regolith dielectric permittivity is complicated by the extraordinary sensitivity of the measured permittivity to the needle contact with the regolith,. Therefore, it is not possible to quantitatively compare permittivities among insertion events. In order to explore possible diurnal variations, we have chosen to normalize the permittivity at a fixed temperature, which allows us to discriminate effectively between nighttime and daytime behavior. Figure 4 shows one such cut through the data, where the dielectric permittivity is normalized to 2.5 at 230K, for all soil measurements. Prior to sol 70, there is no clear dependence of permittivity on regolith temperature, which can be read as a proxy for LMST, However, after sol 70, a distinct pattern of increasing overnight permittivity is seen. This is not a result of small variations in the permittivity of solid mineral particulates, which would have an opposite dependency on temperature from that which is observed. It is hypothesized, but not yet demonstrated, that the systematic increase in dielectric permittivity overnight, subsequent to sol 70, is due to the accumulation of unfrozen H_2O by the cooling regolith during the overnight hours. There is also a substantial increase in the variability of the measured permittivity during daylight hours, which is interpreted as being due to small movements of the RA, due to increased atmospheric turbulence during the day.

References: [1] Zent *et al. JGR,* In Press, 2009; [2] Hudson *et al. LPSC XL*; [3] de Vries, *Soil Sci.*, **73**, 83-89, 1952; [4] Carlslaw & Jaeger, *Conduction of Heat in Solids*, Oxford, London, 1959; [5] Putzig, et al., LPSC 2426, 2006.

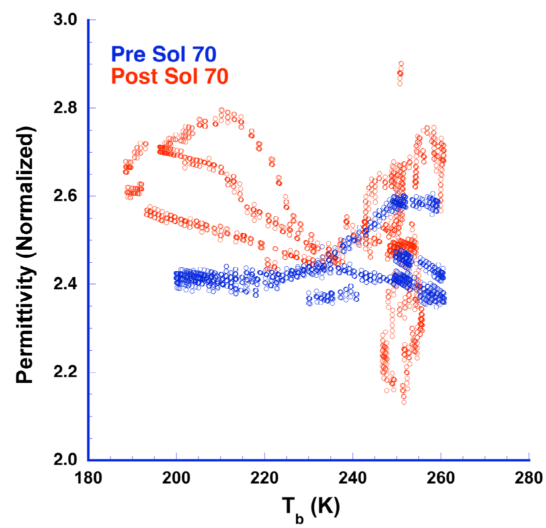

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Figure 4. Regolith dielectric permittivity before and after sol 70. Subsequent to sol 70, overnight (low T) permittivity shows a systematic increase, which may be the result of accumulation of unfrozen water.