PHYSICAL PROPERTIES OF THE ICY SOIL AT THE PHOENIX LANDING SITE. H. U. Keller[1], M. R. El Maarry[1], W. Goetz[1], S. F. Hviid[1], W. J. Markiewicz[1], M. Hecht[2], M. Madsen[3], M. Mellon[4], D. Ming[5], W. T. Pike[6], P. Smith[7], U. Staufer[8], and A. Zent[9], [1]MPI für Sonnensystemforschung, in 37191Katlenburg-Lindau, Germany, [2]Jet Propulsion Laboratory, [3]Earth and Planetary Physics, Niels Bohr Institute, [4]Laboratory for Atmospheric and Space Physics, University of Colorado, [5]NASA-Johnson Space Center, [6]Optical and Semiconductor Devices Electrical and Electronic Engineering, Imperial College, [7]Lunar and Planetary Laboratory, University of Arizona, [8]Technische Universeit Delft, [9]NASA Ames Research Center

Introduction: The geological landscape of the Phoenix landing site is typical of the Vastitas Borealis plains [1]. It is close enough to the Planum Borealis that it is covered by carbon dioxide ice in winter. The polygons are visible from orbit and dominate also the panoramic images taken by the Surface Stereo Imager (SSI). These structures are generated by long term and periodic (seasonal) cycles of contraction and expansion of the subsurface ice. The thermal conductivity and porosity of the regolith covering the ice control the temperature variation of the permafrost and its exchange of water vapour with the atmosphere. Physical properties of the regolith are studied by closeup imaging using the Robotic Arm Camera (RAC) to look at the soil samples collected in the scoop of the Robotic Arm. More detailed investigations make use of the Optical Microscope (OM).

The regolith layer: An early (Sol 5) inspection of the area underneath the lander looking towards its southern leg revealed the extended near surface ice table (Fig. 1). The thrust of the retro rockets obviously swept away the layer of soil that covered the ice table. This view of *Holy Cow* confirmed already before the start of the science operations that the ice table of the polygons is covered by a rather thin layer of regolith in excellent agreement with predictions from Gamma Ray Spectrometer (GRS) observations [2], [3] and based on model interpretations of the seasonal cycle in the troughs between polygons [5] and from large-scale thermal modelling of polygon formation [6], [7].

The thickness of the regolith layer underneath the southern foot of the lander can be estimated from the shadows of the leg structures to lie between 5 and 10 cm. Regolith is piled up underneath the centre of the lander 3 to 4 times its original depth. No piling up of the "excavated" material is visible around the lander. The retro rockets moved more soil material during the final stage of the landing than was excavated by the lander operations.

This regolith layer appears to consist of fine clumpy soil and is sparsely interrelated with mostly rounded rocks (one is visible on the right hand side of Fig. 1). The sizes of the clods range from few mm (the resolution limit) to several cm. Even though the clods of the center pile were violently moved by the rocket exhausts their appearance and size distribution are similar to soil on the outside perimeter and found in the digging area. This immediately suggests that the clods are strongly held together by cohesive forces. Probably, only a minor fraction of the covering layer was "pulverized" and blown away.

The cleared terrain reveals a well-defined flat and relatively smooth icy surface. Later observations (Sol 89 and later) show a slight increase of roughness. Lag accumulated slowly even in areas under the lander that were in the shade during the day and only weakly illuminated by the midnight sun. Ice cannot survive on the surface at the climatic conditions during the Phoenix observations. The formation of a lag was also observed at a nearby, but better resolved ice area named *Snow Queen* as well as in the *Snow White*

Fig. 1 – Images of *Holy Cow* taken on Sol 5 by RAC reveal the extended ice table under a few centimeters of regolith forming the polygons.

Soil properties: Already the first scoops of soil contained centimeter-sized icy clods. No pebbles were visible. Leaving the soil samples in the scoop overnight revealed pronounced changes. Features appeared similar to those of desiccated muddy soil (Fig. 2) indicating a relaxation of the angle of repose. On one occasion a 2 – 3 cm clump near the blade of the scoop disintegrated (collapsed) overnight (Fig. 3). This shows that the clumps of soil are of very fluffy nature. It is clear that once samples were separated from their locations on the surface and stored for extended time (hours) in the scoop, the cohesion of the soil strongly decreased and material started to slide down slopes within the scoop or on the doors of TEGA (inclined by 45°), in a manner resembling mini-landslides.

The ice surface excavated at *Snow White* is smooth and looks dark because it is mixed with finely distributed dust. Samples taken by rasping were put into the scoop as small chips that clumped together within an hour before delivery to TEGA. In fact, the soil stuck at the scoop walls and would not fall out even when the scoop was pointed perpendicularly down. As a consequence, it was not possible to deliver the sample to TEGA. Lag scraped together from the icy surface was clearly less cohesive and could be delivered to TEGA.

Fig. 2 - Scoop dry-out features, Sol 15 and 16, material taken from top layer of regolith in Goldilocks trench, sample acquired on sol 14 and delivered to OM on Sol 17 (Baby Bear soil)

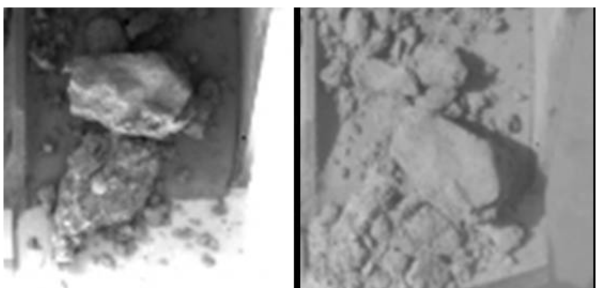

Fig. 3 - Collapsed soil clods in the right half of the scoop, Sol 11 and 12, material from Dodo trench, delivered to TEGA (first part of Baby Bear sample)

RAC images of material in the divot (an area close to the blade of the scoop) reveal agglomerates of fine particles which are well below the resolution limit of RAC and even of the OM (4 µm/.px). Figure 3 shows observations of different samples with a scale down to 24 µm/px.. No particles larger than about 100-200 µm are visible in any of the divot images acquired. In the sample taken from the *Snow White* trench larger clumps appeared to be wrapped by (less than) 100 µm long, spine-shaped particle agglomerations (with particle sizes below the resolution limit) A few silt- and sand-sized grains are hidden in the sample most often covered by dust. Similar sized particles occupy about 20% by volume in the OM samples. The largest agglomerate in the divot image appeares rather compact and slightly elongated about 1 mm in diameter. The colour of the soil samples is uniform, typically reddish. No change with time was detected. The size distribution and nature of the matrix material resemble those inferred from the scattering properties of aerosols [9], [10], [11]. A suspected bi-modal distribution of the inferred clay like aerosols with size peaks be-

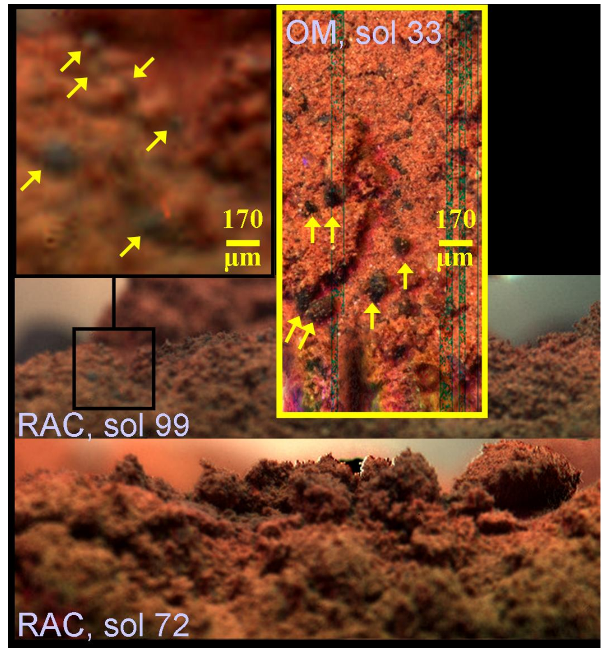

Fig. 3 - A close up look at material on the divot observed with RAC (best scale 24 µm/px) reveal sand sized particles more easily seen in the OM images (4 µm/px)

tween 1 to 2 micron and well below 1 micron is supported by the AFM observations.

The matrix material of the soil on top of the ice is fluffy and composed of micron- (or submicron-) sized particles. Aeolian origin of the soil is supported by rounded appearance of the silt to sand sized grains embedded. The landing site is located within the ejecta blanket of the Heimdall crater. Ejecta material must have been emplaced and subsequently encased in the ice from the solidification of the fluidized material or the ground ice. Ejecta material must have been emplaced and subsequently encased in the ice from the solidification of the fluidized material or the ground ice. The microtektites and agglutinates originate from this impact. The ejecta clasts have been submerged and modified by cryoturbation in the Martian gelisol (permafrost). Aeolian transport and atmospheric fallout continue to mix with the emplaced blanket mat

References: [1] Tanaka et al, (2005) Geologic Map of the Northern Plains of Mars, USGS, [2] Boynton et al. (2002) *Science*, 296, 81, [3] Feldman et al. (2004) *J. Geophys. Res., 109, E09006,* [5] Kossacki and Markiewicz (2002) Icarus 160, 73, [6] Mellon et al. (2007) *7th International Conference on Mars*, #3285, [7] Mellon et al. (2008) *LPSC* XXXIX, #1770, [9] Markiewicz et al. (1999) J. Geophys. Res., 104, 9009-9017, [10] Tomasko et al. (1999) *J.Geophys. Res.–Planets*, *104* (E4), 8987, [11] Lemmon et al. (2004) *Science, 306*, 1753.