GEOLOGIC SETTING AND SURFACE PROPERTIES OF THE MARS PHOENIX LANDING SITE. R. E. Arvidson[1] and The Phoenix Science Team, [1]Earth and Planetary Sciences, Washington University in Saint Louis, Saint Louis, MO, 63130.

Introduction: The Phoenix Lander touched down just before the northern summer solstice at 68.22° N, 234.25° E (areocentric) and operated for 152 sols. The lander is located on patterned ground superimposed on ejecta deposits from the nearby bowl-shaped 10 km Heimdall crater. The robotic arm was able to excavate a dozen trenches on polygon centers, edges, and troughs, exposing and sampling a thin soil cover and underlying hard icy (water ice) soil deposits. Soil mechanical properties are similar to cloddy to blocky soils found at the Viking Lander 2 site and soil materials are dominated by aeolian suspended and saltation loads. Analyses of coordinated orbital and landed observations provide a self-consistent model of grain size distribution and mineralogy of surface deposits, along with the presence of H_2O adsorbed onto surface grains.

Relevant Mission Objectives: Phoenix mission objectives of relevance to material covered in this abstract include: a. Successfully predicting rock and slope distributions to ensure a high probability of successfully landing, b. Landing at a site with geomorphic evidence of periglacial processes and characterizing the nature and timing of those processes, and c. Sampling and characterizing soil and icy soil to understand the current and past environments of deposition. These topics are covered in order in sections that follow.

Geologic Setting and Hazard Predictions: Phoenix landed ~20 km to the west-southwest of the ~10 km diameter bowl-shaped Heimdall Crater [1]. Detailed geologic mapping of the region surrounding the landing site shows that the landforms and deposits are dominated by ejecta from Heimdall that has been differentially eroded by wind [2]. The emplacement of Heimdall is estimated to be ~0.5 Gy [2], making the Phoenix site both the highest latitude and youngest landing site on Mars. The ejecta morphology is consistent with emplacement as a vapor-charged, ground hugging flow that strongly altered pre-existing surfaces, including removing rocks and smoothing the topography. In fact, the prelanding predictions focused on rock and slope size distributions both proved correct and the ejecta surface provided a safe-haven site within the overall rocky northern plains.

Geomorphology: The geomorphology of the landing site as seen from orbit and lander-based imaging is dominated by patterned ground [3]. Phoenix touched down at a location that allowed the 2.35 m long robotic arm to excavate trenches and acquire samples from the top (Wonderland polygon, Snow White trench, Fig. 1) of a polygon, the side (Humpty-Dumpty polygon, Dodo-Goldilocks trench) of a polygon, and a trough located adjacent to a polygon (Stone Soup trench to south of Humpty Dumpty). Detailed measurements of the polygon plan-view patterns and relief, the observation that many of the rocks are within troughs, and evidence of recent cracks imply that the patterned ground is an on-going process and due to sand-wedge formation as opposed to sublimation [2,3,4]. Sand wedge polygons form as the hard icy soil elastic strength is exceeded during cold periods, producing fractures filled in by aeolian deposits. Subsequent warming does not allow the expanding polygons to close the filled cracks and, as a consequence, the polygons bow upward. Rocks are also recycled to troughs as they are "lifted" up onto polygon surfaces and gradually migrate to trough regions. The dominance of cryoturbation processes at the landing site is also evident in the lack of aeolian features such as ripples or dunes.

Fig. 1 – Surface Stereo Imager false color image of the Snow White Trench where back-hoe, scraping, and rasping succeeded for acquisition of the icy soil sample, Wicked Witch, for delivery to TEGA. The array of dark splotches at the bottom of the trench are ~1 cm wide rasp holes into icy soil. Rosy Red surface soils were acquired from the trenches visible on the upper left portion of the image.

Soils and Icy Soils: The dozen trenches excavated and numerous samples acquired by the robotic arm during the Phoenix mission (Table 1) show that several cm of cloddy to blocky soil deposits overlie icy soil in polygons whereas deeper soil deposits are found in troughs (Fig. 1) [4]. Combined analysis of soil spectral reflectance properties using Phoenix Surface Stereo Imager 15 band data (~0.4 to 1.0 μm) [5], Robotic Arm Camera images [6], Optical Microscope color images and 3 band reflectance values [7], and Mars Reconnaissance Orbiter CRISM observations from

~0.4 to 3.8 μm [8] provide a self-consistent view of soils dominated by silt to clay sized aeolian dust, mixed with sand grains introduced to the site by aeolian saltation, together with locally-derived lithic fragments.

Hard icy soil encountered in the Snow White trench is grain-supported, based on the minimal change in volume after several sols of sublimation loss of ice (Fig. 1). This pore ice dominates the exposed icy soil table, except for Dodo-Goldilocks, which based on spectral properties and significant volume loss on sublimation, was mainly ice.

Mechanical properties of the soils are similar to those found for the Viking Lander 2 site and fall into the category of cloddy to blocky soils [9]. This inference is based on slope angles for trenches, a compressive failure test in which the scoop bottom on the robotic arm was used to deform the surface near the southwest wall of the Dodo-Goldilocks trench, and retrieval of mechanical properties by modeling robotic arm dig forces.

Analysis of Mars Express OMEGA data for the Phoenix landing site (and latitudinal band) shows a strong and broad absorption feature at ~3 μm that is interpereted to be due the presence of fundamental and overtone vibrations of surface H_2O, perhaps combined with metal-OH features. There is also a 1.9 μm feature interpreted to be a combination band due to H_2O vibrational modes [10,11]. These bands are also evident in CRISM data acquired while Phoenix observations were also underway. The minimal amount of water released at low temperatures during the TEGA runs, combined with the minor signature of hydrated mineral decomposition at high temperatures [12], imply that only a small amount of adsorbed water on mineral grains is responsible for the orbital spectral signatures. This inference is undergoing experimental verification using the ambient conditions measured by the Thermal Electrical and Conductivity Probe [13] and weather station [14] during the time in which CRISM observations were acquired.

The adsorbed H_2O may explain the cloddy nature of the soils, although laboratory work is needed to ascertain whether or not the soil Ca-carbonate identified by TEGA [11] or the perchlorate identified during the MECA Wet Chemistry experiments [15] are in part or wholly responsible for this soil property. In any case it is clear that the soils are not simply a loose aeolian deposit, but rather have been processed into cloddy to blocky materials once emplaced at the landing site.

References: [1] Arvidson et al. (2008) *JGR, 113,* E00A03. [2] Heet et al. (2009) *LPS XL,* this volume. [3] Mellon et al. (2008) *JGR, 113,* E00A23. [4] Mellon et al. (2009) *LPS XL,* this volume. [5] Lemmon et al. (2009) *LPS XL,* this volume. [6] Keller et al. (2009) *LPS XL,* this volume. [7] Pike et al. (2009) *LPS XL,* this volume. [8] Murchie et al. (2007) *JGR, 112,* E00A23. [9] Moore et al. (1987) *USGS Prof Paper 1389.* [10] Jouglet et al. (2008) *JGR, 112,* E08S06. [11] Milliken et al. (2008) *JGR, 112,* E08S07. [12] Boynton et al. (2009) *LPS XL,* this volume. [13] Zent et al. (2009) *LPS XL,* this volume. [14] Whiteway et al. (2009) *LPS XL,* this volume. [15] Hecht et al. (2009) *LPS XL,* this volume.

Instrument	Trench	Sample Name	Sample Type
MECA OM-2	Goldilocks	Mama Bear	Surface
MECA OM-1	Rosy Red	Rosy Red	Surface
MECA OM-10	Snow White	Sorceress	SPAI
MECA OM-8	*UNK*	Mother Goose	*UNK*
MECA OM-7	Snow White	Wicked Witch	SPAI
MECA OM-6	Dodo-Goldilocks	Golden Key	SPAI
MECA OM-5	Stone Soup	Golden Goose	Subsurface
MECA OM-4	Under Headless	Galloping Hessian	Under Rock
MECA WCL-0	Rosy Red	Rosy Red	Surface
MECA WCL-1	Sorceress	Sorceress	SPAI
MECA WCL-0	Rosy Red	Rosy Red (redelivery)	Surface
MECA WCL-3	Stone Soup	Golden Goose	Subsurface
MECA WCL-3	Stone Soup	Golden Goose (redelivery)	Subsurface
MECA WCL-2	Snow White	Sorceress 2	SPAI
TEGA-4	Goldilocks	Baby Bear	Surface
TEGA-0	Snow White	Wicked Witch	SPAI
TEGA-5	Rosy Red	Rosy Red	Surface
TEGA-7	Burn Alive	Burning Coals	Subsurface
TEGA-1	N/A	N/A	Blank
TEGA-6	Rosy Red	Rosy Red	Surface
TEGA-3	N/A	N/A	Blank

Table 1 – List of samples acquired and delivered during Phoenix mission. SPAI = Scrape Pile Above Ice, UNK = Unknown source for sample.