

OVERVIEW OF THE PHOENIX MARS LANDER MISSION. P. H. Smith¹ and the Phoenix science team, ¹Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721, psmith@lpl.arizona.edu.

Introduction: The Phoenix lander is the next mission to study the surface of Mars in situ. By studying the active water cycles in the polar region, it complements the Mars Exploration Rovers that look at the ancient history of Mars contained in the solid rocks. Without mobility, Phoenix explores the subsurface to the north of the lander, studying the mineralogy and chemistry of the soils and ice.

Scientific Objectives, Phoenix Follows the Water: NASA's crosscutting theme to "follow the water" proves to be difficult on a desert planet. Besides tiny abundances of water vapor in the thin atmosphere and exposed water ice on the northern polar cap, only vestigial remnants recall the flowing rivers and crater lakes from ancient times.

This has changed. Boynton et al. [1] announced early in 2002 that large amounts of water ice are clearly seen by the Odyssey Gamma Ray Spectrometer in the circumpolar regions. Modeling the gamma ray and neutron fluxes, they predict that high concentrations of ice, up to 80% by volume, are to be found within 50 cm of the surface.

The Phoenix mission targets the northern plains between 65 and 72 N. High-resolution images from the Mars Orbiter Camera on the Mars Global Surveyor spacecraft show a "basketball-like" texture on the surface with low hummocks spaced 10's of meters apart; polygonal terrain, or patterned ground, is also common. These geologic features may indicate the expansion and contraction of the permafrost.

Science goal #1: Study the history of water in all its phases. The circumpolar plains are active and hold clues to the cycle of water transport on Mars. Orbiter measurements show large seasonal variations in the atmospheric humidity and CO₂ frost blanketing the winter surface.

Quantifying the volatile inventory locked into the arctic soils and the water chemistry of wet soils, even at one location, is a giant step toward modeling the weather processes and climate history of

Mars [2].

Liquid water changes the soil chemistry in characteristic ways. Obliquity wander and precession are known to strongly influence the climate on time scales of 50,000 years or more. Does the water ice melt and wet the overlying soil on cycles commensurate with orbital dynamics?

Science goal #2: Search for evidence of a habitable zone. Microbial colonies can survive in a dormant state for extremely long periods of time. Recent work [3] shows that as water ice melts onto soil crystals at temperatures as cold as -20 C microbes are activated and are able to search for food. As temperatures increase, growth and reproduction begin.

Instruments on the Phoenix lander receive samples of this biological paydirt and test for signatures related to biology. Organic molecules are easily detectable in small concentrations. A blank is used to discriminate terrestrial contamination. Other experiments determine the chemical and paleo-hydrological properties of the soils in both dry and wet conditions.

Science goal #3: Study the climate and weather of the northern polar region throughout the summer season. Deciphering the interaction between the atmosphere and the volatiles sequestered within the regolith requires that the boundary layer processes must be better understood. Therefore, besides the standard MET station that measures temperature (air and surface) and pressure, Phoenix will include a humidity sensor and the capability to measure aerosol opacity and cloud height using lidar scans and solar imaging.

With this suite of measurements, the transport of water vapor and dust can be tracked throughout the summer season when volatiles may be expected to escape from the regolith. The turbulent eddies and dust devils that characterize and active convective layer can also be monitored sol by sol and compared with mesoscale models developed for the region.

Baseline Mission: Phoenix will launch in August 2007 on a Delta 2925 launch

vehicle from Cape Canaveral, Florida. The spacecraft employs a type II trajectory to Mars and arrives in May 2008. The entry, descent, and landing (EDL) risks are mitigated in many ways: strict adherence to the return-to-flight recommendations, a well-funded test program started in Phase B, reduced entry velocity from MSP'01, lower velocity parachute deployment, longer time on parachute due to the low altitude of the northern plains, a slow descent velocity on thrusters, and an impact-resistant lander.

The science instruments that Phoenix brings to Mars are chosen for their ability to analyze the ice and soils of the arctic region. Images from the descent imager (MARDI) and the panoramic camera (SSI) place the site into geologic context and determine accurate location within remote sensing databases. Along with calibration data, these images are returned within the first few sols of the mission. Stereoscopic images of the digging area are then ported into the software tools that are used to command the trenching operations with the robotic arm (RA).

After the initial assessment of the landing site by the science team at the Science Operations Center in Tucson, Arizona, the primary science phase of the mission begins with the collection of surface samples. Two major science instruments receive and analyze the samples. The first is the thermal evolved gas analyzer (TEGA). A sample is delivered to a hopper that feeds a small amount of soil into a tiny oven, which is sealed and heated slowly to temperatures approaching 1000 C. The heater power profile necessary to maintain a constant temperature gradient contains peaks and valleys that indicate phase transitions. For instance, ice will show a feature at its melting point of 0 C and carbonates between 200-300 C.

Gases driven from the sample are combined with a carrier gas and piped to a mass spectrometer. The spectra of the gases change as a function of release temperature. Isotope ratios for H, O, C, and N as well as heavier gases like Ar and Xe provide scientific clues to the origin of the volatiles.

The second instrument provides a mi-

croscopic, electro-chemical, and conductivity assessment (MECA) of the soils. Microscopic examination of tiny grains (less than 200 microns diameter) gives clues to the emplacement process: Aeolian, lacustrine, or fluvial. A probe on the RA scoop measures the electrical and thermal conductivity of the soil.

Another interesting experiment is the MECA wet chemistry laboratory. Small samples are delivered and sealed into a warm beaker, and water is added to the soil while stirring. Special chemical sensors return data concerning the water chemistry including: the salt content and its composition, the acidity, and the trace mineral concentration.

This experiment provides basic information that every farmer or biologist requires in order to assess the habitable potential of the wet soils. On Earth, alkaline soils are limestone rich and acidic soils contain sulfur; micro-organisms adapt differently to these environments. Are the soils capable of sustaining life during a wet period on Mars?

Throughout the first 90 sols of the missions the RA trenches either to an impenetrable ice layer or to 50 cm. Scientifically interesting layers in the trench will be identified and analyzed.

The meteorological station records the daily weather. Atmospheric pressure, temperature, and humidity are monitored hourly along with the atmospheric opacity measured by SSI solar observations. Periodically, the mass spectrometer samples the atmosphere directly, to measure atmospheric composition and isotopic ratios. The Canadian LIDAR pulses a powerful laser vertically into the planetary boundary layer and captures the return signal versus time of flight.

References: [1] Boynton, W.V. *et al.* (2002) *Science* **297**, 81. [2] Smith, M. D. (2002) *JGR* **107**, 5115. [3] Jakosky, B. M. (2003) *Astrobiology* **3**, 343-350.