OVERVIEW OF MARS EXPLORATION PROGRAM 2007 PHOENIX MISSION LANDING SITE SELECTION.

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Introduction: The 2007 Phoenix Lander is designed to touch down on the high northern latitudes of Mars to characterize the surface, acquire and analyze samples of soil and ice, and monitor atmospheric conditions [1]. Entry, descent, and landing (EDL) are critical phases of the mission and require knowledge of specific atmospheric and surface characteristics for success [2]. This abstract focuses on site selection work, including EDL-based requirements, analyses of candidate sites, and a summary of what has been accomplished to date.

Landing Site Requirements: The science objectives associated with the Phoenix Mission require access to sites that are predicted to have relatively thin soil covers over ice or icy soils. This requirement is to maximize the probability, using the robotic arm, of sampling soils, ice, and icy soils for characterization of textures and other physical properties, volatile phase mineralogy and isotopic composition, aqueous chemistry, and the overall biologic potential. In addition, the site should exhibit morphologic patterns indicative of interactions between volatiles and soils (e.g., patterned ground), and be located in a region where meteorologic observations can facilitate a mesoscale understanding of atmospheric dynamics.

In addition to science objectives there are key engineering requirements that must be met to ensure successful EDL phases of the mission:

a. Location between 65° and 72° N latitude
b. Altitude below -3.7 km relative to MOLA-defined geoid
c. Slopes less than 16° at all scales
d. Rock areal abundances less than or equal to the 18% found at the Viking Lander 2 site (~48° N and an analog site for higher latitudes)
e. Wind velocities (<20 m/s below 40 km) and gusts that are relatively benign

Site Selection Work: Initial work on site selection focused on use of Odyssey GRS data to infer the depth of dry soil covering ice or icy soil within the latitude range of interest [3,4], coupled with geomorphic, slope, and rock abundance analyses [5-8]. Four broad regions were chosen for further detailed study largely based on the predicted depth of dry soil cover over ice or icy soil (Fig. 1). Odyssey THEMIS [9], Mars Global Surveyor MOC [10], Mars Express HRSC [11], and OMEGA data [12,13] were requested and analyzed over the regions. Additional constraints on dry layer soil thicknesses were provided by modeling the depth to stable ice [14], and tracking short and long term surface temperature trends by using Mars Global Surveyor TES data [15]. The results show that local winds are dominated by storm systems that travel with the westerly polar jet [16]. Mesoscale atmospheric modeling was also carried out for each region. The strength of these storms may vary somewhat between regions, but winds from these storms were found to be acceptable for EDL in all regions [17].

Down Selection to Final Box and Ellipses: Region B was initially chosen as the prime landing area because detailed analyses of slopes from MOLA-based topography [18], coupled with elevation maps derived from MOC stereo analyses and photoclinometric solutions [6], showed acceptable slopes. Further, boulder abundance estimates from MOC high-resolution data [7,8], detailed mapping of hazards [19], and consideration of albedo, thermal inertia, and radar scattering characteristics all showed that Region B met landing safety requirements. It had intermediate predicted depth to ice (soil cover several to ~20 cm thickness), and areally extensive smooth plains. Importantly, it also had the lowest altitudes of the three Regions and thus provided considerable EDL safety margin. Three (150 km by 75 km) boxes within Region B were chosen for new orbital coverage and detailed site characterization and certification work. The box locations were selected to minimize large-scale hazards and to cover a wide latitudinal range for landing (southerly box maximized estimated soil cover whereas northerly box maximized orbital telecommunication coverage during the mission. Middle box provided an intermediate and third location). Because the azimuthal orientation of the landing ellipse shifts with launch date and the length of the long axis changes with latitude, the box size was chosen to encompass all possible ellipse sizes and orientations.

Unfortunately the first HiRISE images of the preferred landing sites for Region B, with 0.31 m/pixel spatial resolution, showed that very rocky areas covered impact craters (even subdued ones) and selected polygon interiors. It was impossible to place acceptable landing error ellipses in any of the preferred regions within the boxes or anywhere within Region B because of the random nature of the craters and rocky polygon interiors. This discovery led to a coordinated effort with the HiRISE Team to acquire images across the entire latitudinal girdle. Region B and most of the latitudinal girdle accessible to Phoenix is underlain by the Vatitas Borealis Formation and exhibits the highest rock densities over impact craters [20]. The focus soon turned to Regions A and D, since these areas are largely covered by a debris mantle that consitutes the Scandia Formation [20]. HiRISE-based rock abundances within Regions A and D were found to be an order of magnitude less than within the Vastitas Borealis Formation.

Three boxes were defined in Regions A and D to focus additional acquisition of HiRISE images within possible ellipse boxes. THEMIS predawn thermal infrared image data, which proved very valuable in finding low rock abundance areas across the entire latitudinal girdle, were used in concert with hand-generated and automated rock counts in the boxes to estimate rock densities beyond the HiRISE coverage. Further, fine-scale (down to 2 m length scale) topography and slopes were generated from HiRISE stereo images. Longer length scale slopes were estimated from MOLA data. All of the data were used to select the highest priority box (Box 1) (Fig. 2,3) within Region D for detailed assessments and final ellipse placements. Rocks abundances are low and slopes are typically <3° even at fine scales. Work is now proceeding on defining final ellipse placements before launch in August 2007. Additional HiRISE images of the candidate landing sites will be scheduled when atmospheric and lighting conditions allow in early 2008.

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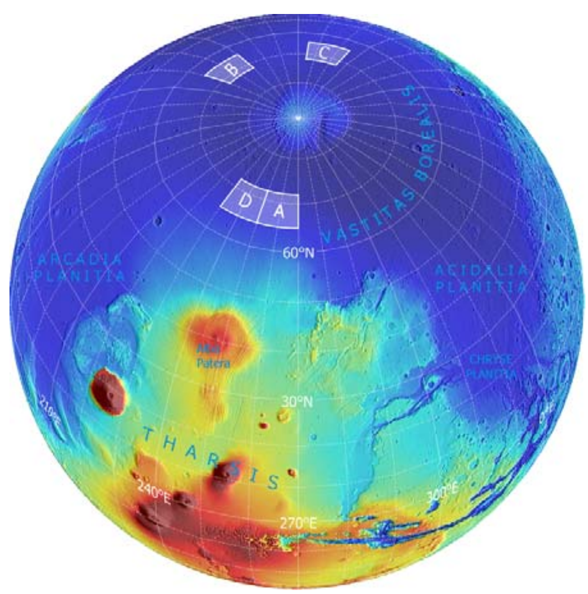

Figure 1. Polar perspective view of MOLA topography with Regions A, B, C, and D shown. Each Region covers the latitude range from 65° to 72° N. Region A covers 250° to 270°, B 120° to 140°, C 65° to 85°, and D 230° to 250° E.

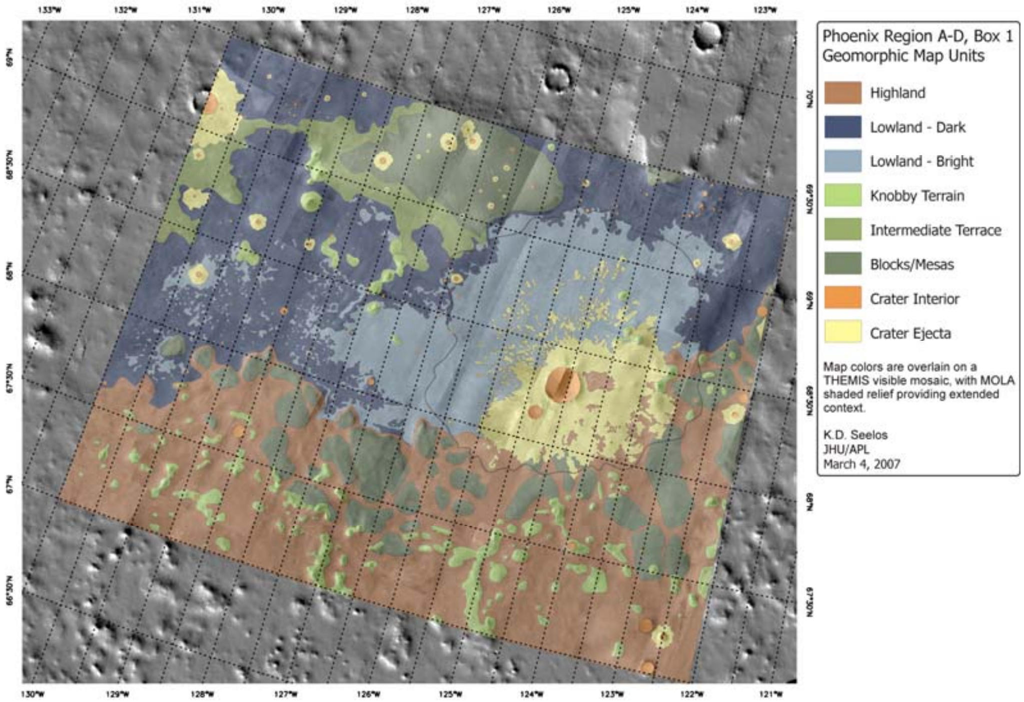

Figure 2. Geomorphic map of Box 1 located within Region D. Unit colors correspond to terrains defined on the basis of MOLA topography, THEMIS visible data, and CTX data.

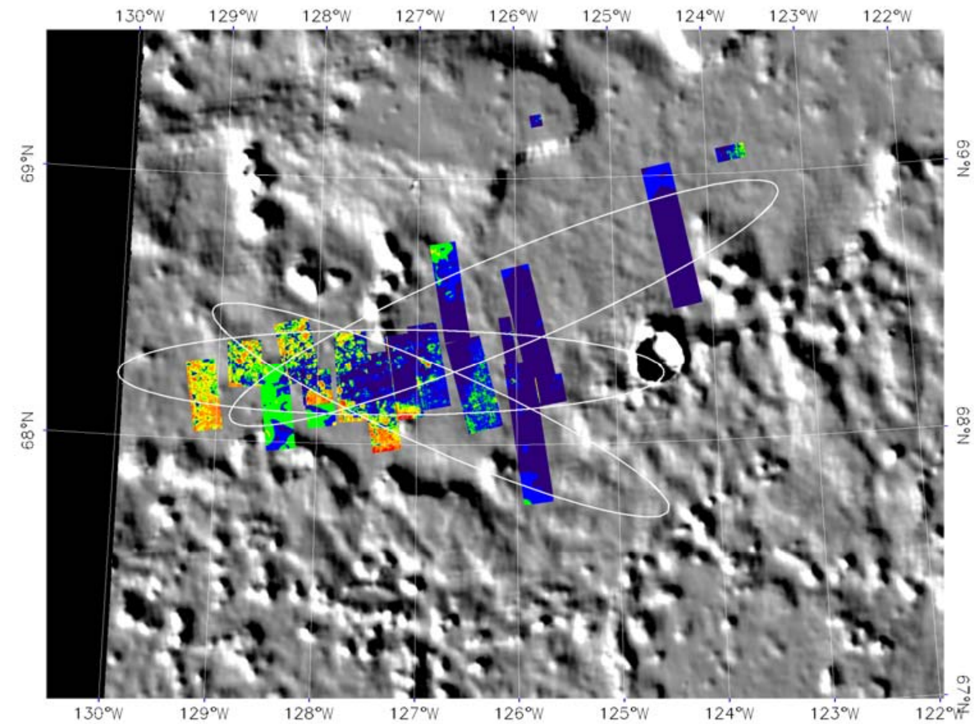

Figure 3. MOLA-based shaded relief map for Box 1, Region D overlain with rock abundance estimates derived from automated rock counting and hand counts from HiRISE images (blue is low and red is high). Rock abundances are typically 0 to 10 rocks larger than a meter per hectare, providing an acceptable landing risk. Three ellipses are shown for opening to closing of the launch window. These ellipses are preliminary and will be updated before launch.