MARS POLAR ROVER AND ICE SAMPLING EXCURSION. W. M. Calvin[1] and C. L. Kahn[2], [1]Dept. of Geological Sciences, Univeristy of Nevada, Reno, MS 172, Reno, NV 89557, wcalvin@unr.edu, Jet Propulation Laboratory, Pasadena, CA 91109

Introduction: Included in the high priority New Frontiers class missions for Mars in the "Visions and Voyages" Decadal survey, are 5 mission concepts to capture important science following on the success of the Phoenix lander [1,2]. This abstract discusses the science value for a Polar Rover and Ice Sampling Excursion mission and how technological developments for this mission are on the path to advance future Mars Sample Return (MSR), and offer collaborative elements of interest to Human Exploration and the Office of the Chief Technologist.

Science Justification: Following up on scientific results from the Phoenix (PHX) mission and high-latitude ice studies by instruments on MRO and Mars Express, there is strong community support behind a mission to the exposed polar-layered deposits (PLDs) on Mars. This class of missions was subject to a "Rapid Mission Architecture" study [2] resulting in their inclusion in the New Frontier category of missions to Mars. While drilling, roving, and specific orbital observations have been proposed as methods to access the stratigraphy and climate history locked in the PLD, a MER-class rover with a small ice corer could address fundamental science questions related to volatile history and evolution, surface-atmosphere exchange of water and carbon dioxide, and make direct measurement of the climate record preserved in the PLD.

Specific in-situ measurement objectives include:

- Mass, density, and volume of late seasonal CO_2 ice in time and space. Grain size, dust content, composition, and extent of layers.
- Accumulation/ablation rates, linking present accumulation/ablation to observed stratigraphy.
- In-situ measurement of grain size, dust content, composition, and extent of layers in residual H_2O ice.
- Elemental and isotopic ratios relevant to age (D/H) and astrobiology (CHNOPS).
- In-situ measurement of pressure, temperature, winds, at multiple locations with monitoring of seasonal changes in these values.
- Constrain porosity, compaction, and thermal inertia of the residual ice.

These measurements are relevant to a large number of identified strategic knowledge gaps, including novel in-situ instrumentation, improvements in landing, measurements of winds and atmospheric pressure, knowledge of the accessible near-surface resources of interest to future human exploration missions.

Mission Scenario and Strawman Payload: The mission would target the large, low slope plateaus of the Boreale Lingula in the PLD or the lower ice-cemented units in the Chasma Boreal or adjacent to Abalos Mensa for sampling of either upper or lower stratigraphy of the PLD. The mission would take advantage of the MER rover existing design. Elevations, slopes, and surface roughness of the PLD are within the existing design margins of the MER air-bag EDL system. Precision targeting would not be needed and large low-slope areas of the Gemini Lingula and in the Chasma Boreale are within a 100km x 20km landing ellipse (Figure 1). Replacement of the MER mast with a smaller Phoenix mast would allow more room on the rover deck. Hosted payload mass capability could accomodate10 to 20 kg. Based on a preliminary analysis by JPL [3] the MER solar arrays would generate roughly 1200W-hrs, and addition of deployable arrays with larger area could generate 2300 W-hrs/sol or more if stow volume is available. It is assumed that approximately 70 Mb/sol data throughput would be achievable. Demonstrated MER mobility suggests an average traverse rate of approximately 10 mm/s or 36 m/hour. This would include the typical Navcam/Hazcam observations and corrections, path planning, etc. Maximum daily traverse distances assume 100 m as the upper limit (power constrained). Orbital monitoring by MRO has determined the seasonal cap retreat for several martian years suggesting operations at latitudes higher than ~ 80 degrees could make observations in the absence of thick seasonal ice and with good solar exposure (no cloud or polar hood) from Ls 70 (aphelion) to Ls 150, or rougly 150 sols, while power considerations suggest a probable mission lifetime of ~90 sols. Assuming a traverse of 100m/sol the maximum accessible range for the mission would likely be several kilometers.

The science payload strawman concept includes color and navigation cameras (Navcam, Pancam heritage), remote composition for identification of distant targets and interrogation of mixed surface ices using imaging spectroscopy (Mini M3). On a robotic arm (Phoenix class) would be a small drill or ice chipper (MSL heritage), a microscopic imager (MER and MSL heritage), and high resolution spectroscopy for ices, organics and geologic materials (tunable laser, FTIR, or Raman). The drill/chipper itself could also provide information on the strength and geothechnical properties of the ice. The rover would also carry a meteorology package similar to Phoenix.

The utility of this mobile system would be to access different layers of material as the rover traverses upslope or downslope across layer transitions. Based on variations in optical properties observed from orbit, many layers manifest changes over the scale of 1 meter or less. Through the mission, the rover could be expected to operate in one of two modes: fine sampling during which elemental and compositional analysis is completed on rock core or chip samples excavated from the near-surface (3-5cm depth) at close spacing (few meters) and long-duration sampling where the rover would traverse a pre-specified interval (10's of meters) between samples. Given the amount of time anticipated to acquire and analyze a sample, sampling more frequently than once or twice per day might not be feasible regardless of the distance between sample sites. As the rover traverses from site to site, imaging and spectrometer systems would acquire morphology and compositional data.

Detailed cost modeling for this and other scenarios was not performed as part of the decadal survey (i.e. no CATE report). First order cost analysis was conducted based on analogy and place this concept in a New Frontiers class.

Links to Strategic Knowledge Gaps: This mission concept can directly contribute to the identified challenge areas by creating and furthering technologies to investigate the shallow subsurface of Mars and developing light weight instruments for triage of samples for investigation (challenge areas 1 and 2). Detection of organic matter in ice samples is a priority, as ices can be expected to preserve these elements as seen in terrestrial ice cores (Challenge area 4). The mission concept would provide direct measurement of atmospheric winds in a unique latitude band, further constraining atmospheric models for future landing (Challenge area 6). While guided entry is not required to achieve the science goals, it could be added to this mission and the concept could be used to further EDL designs for higher accuracy landing (area 7). This mission concept could be packaged as part of a paired delivery of rovers to different locations on the surface, potentially contributing to lowering the cost of delivery to the martian surface by multiple delivery from a single orbiter, it could also contribute to novel methods of surface exploration, new approaches to mobility, as the PLD present a unique material for trafficability and navigation (Challenge areas 11,12, and 16).

The P-SAG group has identified atmospheric modeling, radiation, understanding water resources and atmospheric and dust characterization as important gaps. The measurements made by this mission concept would further our understanding of many of the issues related to putting humans in orbit at Mars at some future date.

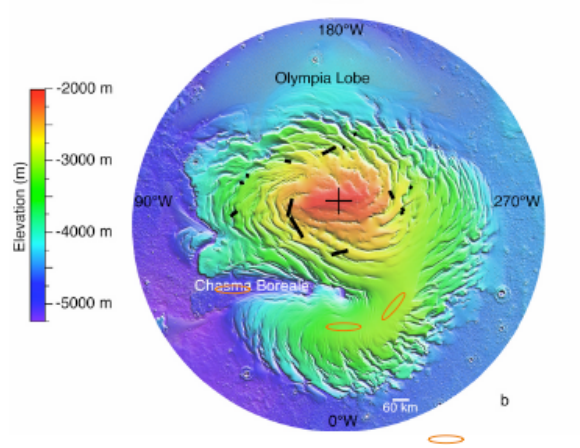

Figure 1: Approximate MER landing ellipse (red ovals) (100km x 20km) placed in several locations on the Boreale Lingula or in Chasma Boreale show that precision guided entry is not required. Elevations are well below the -1.3km bound for the EDL system.

References: [1]Visions and Voyages, NRC Planetary Science Decadal Survey, 2011. [2] MCS Final Report: Mars Polar Climate Concepts, NRC/JPL, 2010. [3] S. Dawson, Jet Propulsion Lab, personal communications.