M-PRESS: Mars-Polar Reconnaissance of Environment & Subsurface Stratigraphy. S. Byrne[1], P.O. Hayne[2], I.B. Smith[3], and K. Zacny[4], [1]University of Arizona, Tucson, AZ. [2]University of Colorado, Boulder, CO. [3]Planetary Science Institute, Denver, CO. [4]Honeybee Robotics, Pasadena, CA. Correspondence: shane@lpl.arizona.edu

Motivation: Climate change on terrestrial planets is perhaps the most pressing scientific issue of our day, and its study is of broad significance. Mars' continuously varying orbital elements lead to climatic variations that (like on Earth) redistribute ices and affect seasonal volatile cycles. Mars' climate represents a simplified version of Earth's in that it lacks oceans, life, thick cloud cover and human activity. Understanding the martian climate record and how it connects to orbital variations represents an achievable goal that helps understanding of terrestrial planet climate.

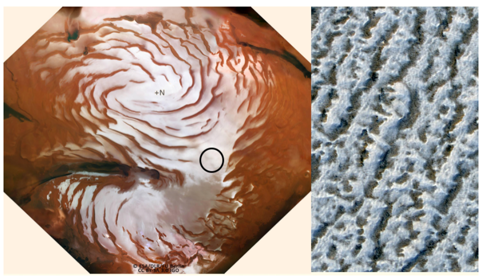

Figure 1. (Left) HRSC mosaic of the NRC with circular area required for a MER-sized landing ellipse of unknown orientation. (Right) example of NRC surface where light/dark patches are ~20m across.

An archive of martian climate exists in the layers of the North Polar Layered Deposits (NPLD). Rapid progress has been made in characterizing these deposits from orbit over the past decade. Radar data show contiguous layering over their ~1000 km extent and ~2 km thickness [1-3]. Imagery and topography of exposures have enabled mapping of layers <1 m thick and detection of periodic signals in their stratigraphy [4-6].

The NPLD are covered with a residual ice cap (NRC, Fig.1) that is the dominant source and sink of atmospheric water vapor for the entire planet. It is composed of large-grained and dust-free H_2O ice [7,8] with finer-grained H_2O-frost present during spring [9].

The NPLD and NRC are a scientifically-compelling target for a lander with three main goals:

1) Quantify NRC/current-climate interaction.
2) Determine what is recorded in NPLD layers.
3) Connect uppermost layers to orbital data

A 2017 Keck Institute for Space Studies study on Mars polar exploration brought together >30 experts to determine required measurements and mission concepts to accomplish these goals. Here, we report on a landed mission that reflects the study's findings.

Implementation: The M-PRESS concept performs year-round meteorology as well as physical and chemical characterization of the surface and subsurface. M-PRESS uses a pathfinder/MER landing system (Fig. 2) to minimize surface contamination and deliver ~200kg. At this latitude, energy-intensive summer activities benefit from constant solar power, while winter meteorology is enabled by RHUs with powersticks.

The NRC is the safest place to land on Mars. It is one of the smoothest locations at MOLA scales [10], and no boulders are present. Its elevation (-4000 to -2000 m) is comparable or lower than other recent sites. Precision landing is not required and MER-scale landing ellipses fit entirely within its boundaries (Fig.1).

Year-round meteorology is enabled by a standard MET package as well as a Differential Absorption Lidar that characterizes the vertical distribution of water vapor and precipitation, a Sonic Anemometer that quantifies near-surface winds and eddy fluxes and a Tunable Laser Spectrometer (TLS) that characterizes near-surface water vapor and isotopic ratios.

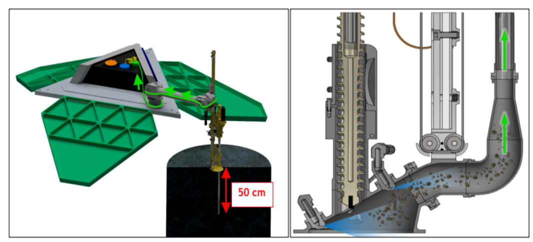

Figure 2: (Left) MER-style lander with deployed 50 cm drill. (Right) Pneumatic sample delivery mechanism.

A 50 cm drill pneumatically delivers samples at ~5 cm intervals to instruments (Fig. 2). A fiber-optic rotary joint and borehole microscopic imager allows characterization of subsurface composition, porosity and layering *in situ*. Samples are analyzed by a TLS (ice isotopes), and a near-IR Raman Spectrometer (abundances of salts, silicates and oxides). A Ground Penetrating Radar connects near-surface layers to orbital observations.

M-PRESS fits the constraints of the Discovery program. The delivery vehicle is build-to-print and over-engineered for an NRC landing. M-PRESS instruments have spaceflight heritage or current TRL levels of 5-6. Cost constraints can be satisfied with an international contribution of one major instrument (<30% payload).

We will present additional detail on the science goals, payload, and relationship to MEPAG goals.

References: [1] Phillips et al., Science, 2008. [2] Putzig et al., Icarus, 2009. [3] Smith et al., Science, 2016. [4] Fishbaugh et al., GRL, 2010. [5] Becerra et al., JGR, 2016. [6] Becerra et al., GRL, 2017. [7] Kieffer, JGR, 1990. [8] Langevin et al., Science, 2005. [9] Brown et al., Icarus, 2016. [10] Aharonson et al., JGR, 2001.