MARS' POLAR LAYERED DEPOSITS GEOLOGY AND HISTORY AS REVEALED BY IMPACT CRATERS. M.E. Landis[1], A.S. McEwen[2], I.J. Daubar[3], P.O. Hayne[4], S. Byrne[2], C.M. Dundas[5], S.S. Sutton[2], A. Britton[6], K.E. Herkenhoff[5]. [1]Planetary Science Institute, Tucson, AZ, USA (mlandis@psi.edu), [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [4]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, [5]Astrogeology Science Center, USGS, Flagstaff, AZ, [6]Malin Space Science Systems, San Diego, CA.

Introduction: Mars' Polar Layered Deposits (PLDs) represent a tantalizing clue in deciphering Mars' climate history. Previous studies have detected recurring patterns in the alternating layers of ice and dust [e.g., 1-2] and made estimates of the accumulation rates required to replicate them [e.g., 3-4]. Data from several Mars years of orbital observations have made significant progress describing the inter-annual variations in the seasonal CO_2 ice and other key controls on the mass balance of the PLDs [e.g., 5]. From thermal and martian obliquity models, it appears unlikely that the current NPLD could have survived beyond 5 Myr before the present [6-8]. Radar layering suggests the NPLD records geologically recent climate shifts [9], in addition to the processes that are generating individual layers visible in the troughs.

However, if and how the PLDs are recording the most recent climate is not yet well understood. In the case of the North PLD (NPLD) there are lines of remote sensing evidence that suggest that they are gaining and losing mass [10-13]. Additionally, from previous crater studies [14-18], the surface age of the SPLD is orders of magnitude older than that of the NPLD. This has major implications for interpreting how climate signals contained within the NPLD and SPLD may overlap, and what era the record within the SPLD represents.

This abstract summarizes previous work on deriving the surface ages of the PLDs from impact crater statistics, highlights where remote sensing data can be used to make progress in the near future, and finally reports on a newly detected, dated small impact crater on the SPLD and implications for near-surface PLD geology at a previously un-studied scale.

PLD surface ages from crater statistics: Impact crater statistics have been frequently used in the literature to determine exposure ages of the near-surface regions of continuous geologic units [19]. Previous impact crater studies of the PLD have used a variety of resolution image data, from Viking to HiRISE [14-18].

Where similar data sets were used to determine the surface age of both the NPLD and SPLD, a several orders of magnitude age difference was found [14]. While key developments to our understanding of the SPLD have changed since the first impact crater studies (including improved resolution image data, the discovery of low radar reflectivity zones [20-21], and the description of two surface geologic units [22]), the resulting large surface age difference between NPLD and SPLD remains [23].

The detection of impacts on Mars in before and after Context camera (CTX) images has allowed for the estimation of the present day impact crater production function (PF) [24] at small sizes, in contrast to previous crater PFs that were scaled to Mars from the lunar record [e.g., 25]. When re-interpreting the surface age of the NPLD using this PF and HiRISE data, a maximum age of ~1.5 kyr for the surface is found [18] vs. a previous maximum age of ~20 kyr [17]. This means that the survival time of a 200 m crater on the surface could be as short as ~1.3 kyr [18, 26].

To calculate infill rate for a 200 m crater, we assume an initial depth-to-diameter ratio of 0.2 and that the inner slope of the impact crater wall is ~20°. If water ice infill is the primary removal mechanism of these craters and the impact flux of [24] is assumed, in ~3.6 years there would be one 25-cm pixel horizontal difference in the extent of intra-crater water ice as observed by HiRISE bin1 [26]. However, if lunar-scaled chronologies [e.g., 23] are used, it would be decades to centuries before 1 pixel differences could be detected [26]. With HiRISE's data collection lifetime extending into its second decade, it may be possible to measure these small but multiple pixel changes in crater fill, and determine which model most closely matches observations.

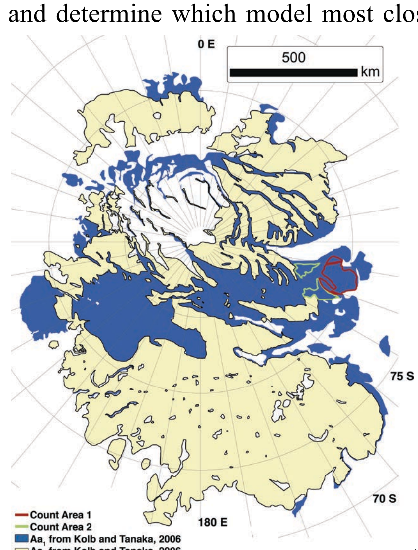

Figure 1. The geologic units of the SPLD mapped by [8] are shown with the two initial count areas (in green and red).

The craters on the SPLD are more numerous and generally larger than those on the NPLD [e.g., 14] and are subject to viscous relaxation [27]. Applying the PF based on observed Mars small craters [24] rather than a lunar PF extrapolated to Mars [e.g., 25], results in a ~200 kyr surface age vs. ~10 Myr surface age for test counting regions in Promethei Lingula (Figure 1).

SPLD crater diameters can range from a few 10s of m to several km in diameter. This broad size range suggests that the impactor population that generated them is most likely some mixture of older, more lunar-chronology-relevant impactors (km scale) and the current, small-impact-generating martian impactor population (~10s m). However, if the crater retention age derived from lunar-like crater production [e.g., 25] best reflects the true age, the SPLD surface is closer to 10s of Myr old. The climate record of the SPLD therefore may not significantly overlap in time with that of the NPLD. Applying models that combine impactor populations may narrow this broad surface age in the future.

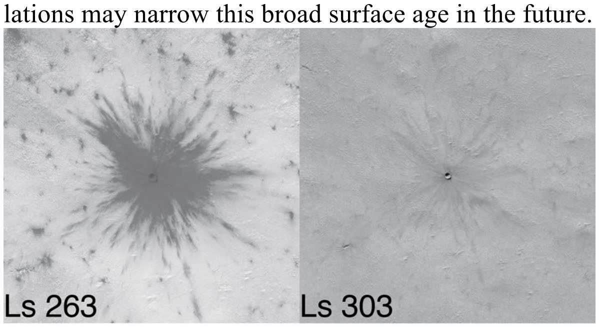

Figure 2. The ~18m diameter new impact crater in two HiRISE images (ESP_057152_0985 & ESP_057970_0985), one with and without seasonal frost coverage. Images: NASA/JPL/University of Arizona.

New results from a dated SPLD impact: The detection of a ~18m diameter impact crater on the SPLD by CTX (formed between July and September 2018, at ~81.5°S, 41°E) provides an opportunity to test assumptions about the strength of the dusty-ice that makes up the SPLD and about the structure of the near-surface SPLD region (Figure 2). The crater ejecta includes very small patches that resemble bare ice in HiRISE color data, but mostly resembles ice-free impacts [28].

From the available HiRISE images of this crater, we can find the relative dust content and particle size of the ejecta. We found the *I/F* values for a piece of flat terrain outside the impact crater ejecta and the crater ejecta. The *I/F* is smaller in the proximal ejecta than on the surrounding terrain, implying that the dust layer excavated to generate it is different in grain size, roughness, or dust content than the air-fall dust on the surface. We will apply a spectral model described in [29] to constrain the dust mixing ratio and grain size, and will report these findings at the conference.

This result will characterize the dust in the upper ~1.8m of the SPLD, assuming an excavation depth of 0.1D [30]. This crater excavation depth within the length scale to which neutron spectroscopy is sensitive (up to ~1 m, depending on composition [e.g., 31]) and can serve in the future as a point of comparison for neutron response models. Studying the near-surface composition, in addition to understanding the recent climate record contained within the SPLD, will also help drive future mission requirements especially for missions studying the shallow subsurface.

In addition to inferring dust properties of the near surface, the depth-to-diameter ratio (d/D) and overall geometry of the dated SPLD crater provides a much needed data point to determine the effect of material strength differences of Mars-temperature ice and rocky targets on overall crater shape. The widely used pi-group scaling of [32] does not contain parameters for water ice, and studying the geometry of this crater vs. other dated impacts on Mars is a key next step.

The new crater d/D can be compared among the dated SPLD impact and other small impacts on Mars. Three NPLD craters (D ~90-120 m) have d/D between 0.17 and 0.21. The mean d/D of dated impacts into lithic targets is ~0.23 [33]. Currently, the HiRISE DTM lab is generating a model for this small impact. We will present results from analysis of this new SPLD crater topography compared to other small, new craters.

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