SEASONAL AND INTERANNUAL CHANGES IN METER-SCALE PITS IN MARS' NORTH POLAR LAYERED DEPOSITS. S. Sutton[1], S. Byrne[1], K. E. Herkenhoff[2], A. S. McEwen[1], [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ (ssutton@lpl.arizona.edu), [2]USGS Astrogeology Science Center, Flagstaff, AZ.

Introduction: The 3-km thick stack of ice and dust layers at Mars' north pole, known as the North Polar Layered Deposits (NPLD), is considered a record of climate cycles [1]. Exposures of the NPLD within large circumferential troughs provide insight into their structure and depositional history. Meter-scale pits of unknown origin were discovered to exist within the NPLD exposures [2]. These features are only resolvable in HiRISE images, at ~25 cm/pixel [3].

Since the discovery of meter-scale pits in Mars' NPLD [2], repeat images of the type locale (84.37N, 254.59E) have been acquired over different seasons and over four Mars Years (MY) to look for changes, formation of new pits, or disappearance of pits (**Table 1**). We present the results of this campaign as well as an updated inventory of locations throughout the NPLD where pits have been identified in HiRISE images. Spatial analysis of their distribution at the discovery site is also considered as a test of formation hypotheses.

Table 1. Repeat HiRISE images taken of the discovery site at (84.37N, 254.59E). Highlighted images are the stereo pair used to generate a digital terrain model, used to orthorectify repeat observations.

HiRISE Observation ID	MY	L_s (°)	Season
PSP_010198_2645	29	127	Summer
PSP_010014_2645	29	134	Summer
ESP_019244_2645	30	143	Summer
ESP_032905_2645	32	1	Early spring
ESP_034672_2645	32	65	Spring
ESP_035173_2645	32	82	Late spring
ESP_035595_2645	32	96	Early summer
ESP_035951_2645	32	109	Summer
ESP_036004_2645	32	111	Summer
ESP_036043_2645	32	112	Summer
ESP_037085_2645	32	151	Late summer
ESP_044193_2645	33	89	Late spring
ESP_044861_2755	33	112	Summer
ESP_045604_2645	33	140	Summer
ESP_046105_2645	33	159	Late summer

Geologic Context and Morphology: The pits are roughly circular, ~1-5 m across, with inward-sloping rims (**Fig. 1**). The sides and bottoms are not discernable in the HiRISE images. Based on illumination angles, the minimum depth/diameter ratio is 0.53 [2]. Their spatial distribution does not immediately appear to form any kind of regular pattern or strong correlation with a given stratum (**Fig. 2)**. They occur in gently sloping exposures of the NPLD (**Fig. 3**). Early spring observations show the effect of the seasonal CO_2 frost deposit, at some locations obscures pits, while at others it makes them more obvious (larger opening, higher contrast with surroundings, e.g. **Fig. 4-C**). The surface of the exposed strata has a striated, pitted texture [4,5], and lacks boulders or talus. The surface texture is rugged on a larger scale than the pits (10s of m planform, ~1 m elevation). They are concentrated at latitudes 75-85N, and do not appear to have a longitudinal preference (**Fig. 3**).

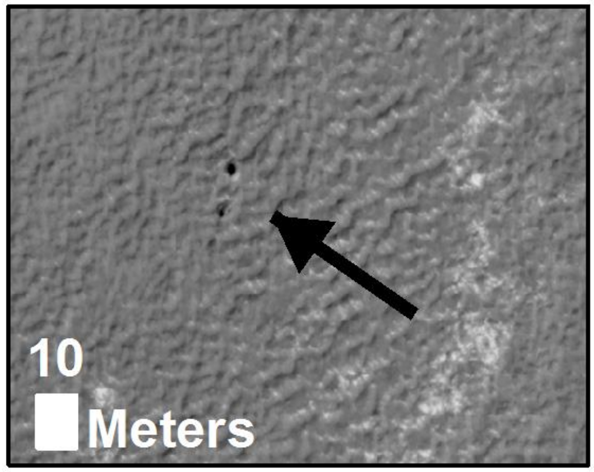

Figure 1. Typical Pits in PSP_010014_2645. Image is nearly frost-free. Illumination is from upper left.

Possible origins. The origin of the pits, both in terms of formation mechanism and timing, is important to understand for its implications for the history of the NPLD. If the pits are forming currently, this implies an active surface process, such as sublimation and/or collapse. If their origin is concurrent with the original deposition of the NPLD, then a process needs to be invoked that explains their physical characteristics and present

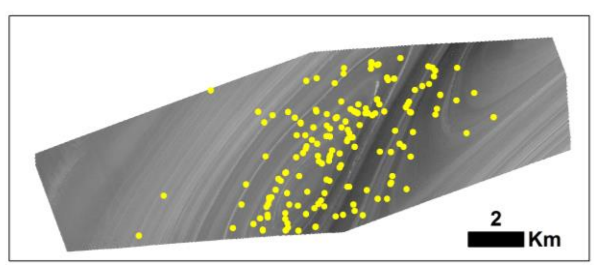

Figure 2. Pit distribution in orthorectified HirISE image PSP_010014_2645 (starred in **Fig. 3**). Symbols are not to scale.

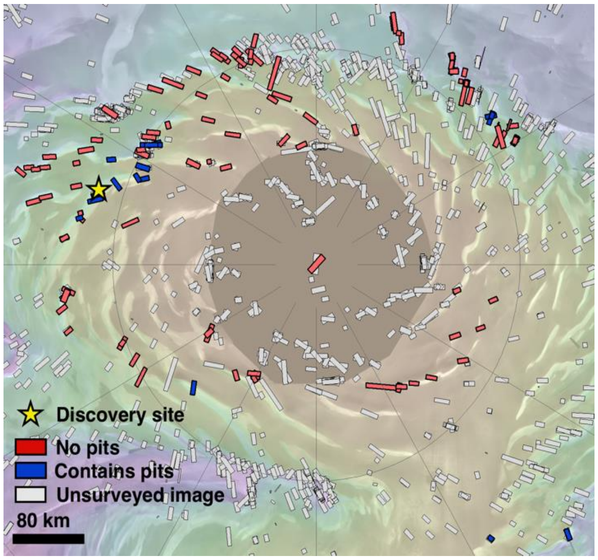

Figure 3. Regional map of the north polar region of Mars from latitude 75N (polar stereographic projection). Basemap is MOLA global elevation over THEMIS day IR. HiRISE image footprints in gray have not been surveyed, red did not contain pits, blue do contain pits.

day setting. Formation hypotheses include (but are not limited to) impact, sublimation of ice lenses or pockets, collapse into a pre-existing void, and thermokarst.

Discussion: The timing and cause of the pit formation is unknown. However, several possibilities are being investigated. Other negative-relief features on Mars such as lava collapse pits [e.g. 6], sublimation pits and fracture collapse pits, do not share the same characteristics or morphology of the NPLD meter-scale pits. It is unlikely that they share similar formation mechanisms. The presence of the pits exclusively in the lower exposures of the NPLD could indicate that these features are related to (possibly) ancient deposition environments, or it could be an observational bias. The low slope exposures may also provide a favorable setting for sublimation of subsurface materials followed by collapse, similar to small pits found in the South Polar Residual Cap (SPRC). Unlike the NPLD pits, the SPLD pits are shallower, wider, and the interior structure is fully illuminated. Fractures exist on the upper surface of the North Polar Residual Cap (NPRC) [5], interpreted to be the surface expression of normal faults, that have similar pits associated with them. The relationship of the pits aligned with these faults and the NPLD pits is unclear, but linear features are not associated with the small pits described here.

Conclusion: Observation campaigns along with mapping and spatial analysis are used to test various hypotheses about the timing and origin of meter-scale pits in Mars' NPLD. The increasing temporal baseline of Mars Reconnaissance Orbiter/HiRISE observations is essential for making precise measurements of any changes, both over seasonal and annual time periods. Understanding the origin and evolution of these features will inform our understanding of the the climate cycles that are recorded in the NPLD.

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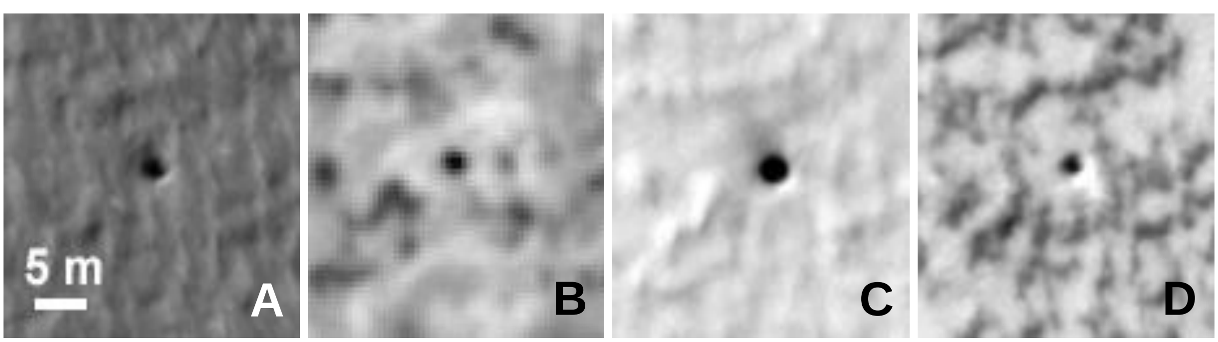

Fig. 4. Changes in one pit near 84.37º N, 254.59º E (starred location in **Fig. 3**). All images are co-registered and illuminated from the upper left . **A)** Detail from a HiRISE image taken in Mars Year 29, in a mostly frost-free scene. **B)** The same pit taken 3 Mars years later, in very early spring. Note: The image has 2×2 binning. **C)** The same pit, later in the spring of the same year. **D)** The same pit just before the start of northern summer. In this partially defrosted scene, the pit opening diameter appears to be similar to that seen in **A).**