INVESTIGATING ENIGMATIC PITS IN THE NORTH POLAR LAYERED DEPOSITS OF MARS. Dora Elalaoui-Pinedo[1], Sarah S. Sutton[1], Chris H. Okubo[2], Shane Byrne[1], V. G. Rangarajan[3]. [1]University of Arizona (1541 E University Blvd, Tucson, AZ 85721, USA, delisaeap@arizona.edu), [2]USGS Astrogeology Science Center, Flagstaff, AZ USA, [3]DLR Institute of Planetary Research, Berlin, Germany.

Introduction: The North Polar Layered Deposits (NPLD) are layers of dust and water ice within Planum Boreum at the north pole of Mars. The NPLD contains spiral troughs that expose interior layers and are capped by a bright north polar residual ice cap. Intriguing features within the NPLD are pits of unknown origin, which typically appear within the troughs as deeply shadowed circular features, usually between 1-5 meters in diameter [1]. Furthermore, similar pits have been identified in the North Residual Cap (NRC), which is the uppermost, ice-rich layer of the NPLD [2]. Understanding the age, evolution, and current mass balance of the NPLD is of major interest in Mars research [3]. The geologic setting and morphology of the pits indicate possible volatile loss that forms the void space, so actively investigating the rate of pit formation and evolution may illuminate recent volatile loss in the NPLD. Ultimately, studying the pits is unexplored research that may further explain the structure of the NPLD and advance our knowledge of Mars' climate history.

Methods: Using images from the High Resolution Imaging Science Experiment (HiRISE) [4] on the NASA Mars Reconnaissance Orbiter, we located and investigated pits in the NPLD. HiRISE is the only instrument with high enough resolution to resolve the pits. We mapped their locations using QGIS, a geographic information system, to explore their formation mechanisms, active surface processes, potential faults, and ice sublimation or deposition.

To investigate the polar pits, we determined criteria for identifying them based on morphology. Pits most often appear as quasi-circular, meter-sized, and deeply shadowed. A limited survey previously identified pits within troughs throughout the NPLD [5]. Some pits can be recognized by light reflected off the surface around a pit that creates a faint crescent outlining one side of the pit, further evidence that the feature is a cavity in the surface. With these criteria for identifying pits, we identified HiRISE images as having confirmed pits, possibly containing pits, or confirmed to have no pits **(Fig. 1)**.

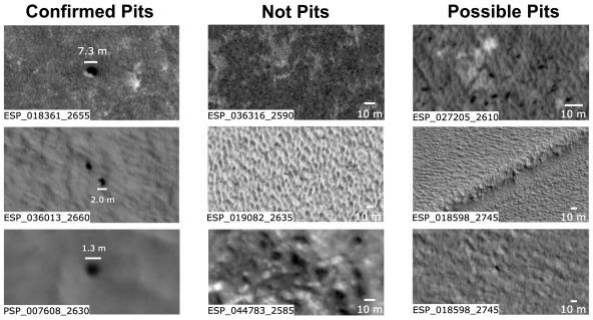

Figure 1. Confirmed pits, not pits, and possible pits located in the NPLD in HiRISE images.

Pits previously identified in the NRC [2] were revisited during this study **(Fig. 2)**. The NRC pits are similar in size and morphology to the NPLD pits but are linearly aligned, possibly indicating the trace of an incipient fault [2].

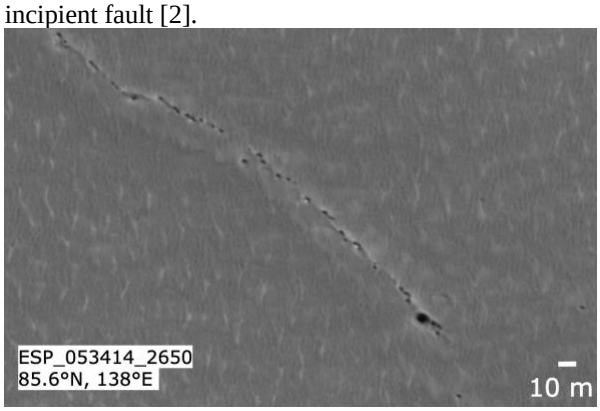

Figure 2. HiRISE image ESP_053414_2650 contains pits that can be seen in a linear pattern.

Using QGIS, we placed the HiRISE image footprints onto the Mars Orbiter Laser Altimeter (MOLA) north polar region base map [6]. To fully examine images, we used HiView, an application for viewing HiRISE images at full resolution. We prioritized analyzing HiRISE images of the troughs between 77° N and 87° N. We also prioritized viewing the highest resolution HiRISE images (25–30 cm/pixel) primarily in the NPLD troughs. The HiRISE image footprint on the map was colored green when pits were found, red when pits were not found, and blue when potential pits were found **(Fig. 3)**. In images with confirmed pits, we mapped the individual pits to display their local distribution**.**

Results: Of the 422 HiRISE images surveyed, 75 contained pits, 34 images were marked as possibly containing pits, and 313 contained no pits **(Fig. 3)**. Within the images identified as containing pits, we mapped 2,025 individual pits. Pits were not found >84.2° latitude. A new location of NRC pits was discovered along a possible fault in HiRISE image ESP_026980_2595 at 79.2° N, 27.7° E (**Fig. 3**). Pits were mainly found in troughs and were not found in the

Basal Unit (BU) of the NPLD, which underlies the NPLD.

We extracted the slope and elevation from the MOLA data at each individual pit location. All pits occur on slopes <21.2°, with 87.5% of the pits found on slopes <5°. Elevations of individually mapped NRC pits and NPLD pits were plotted on a histogram **(Fig. 4)**.

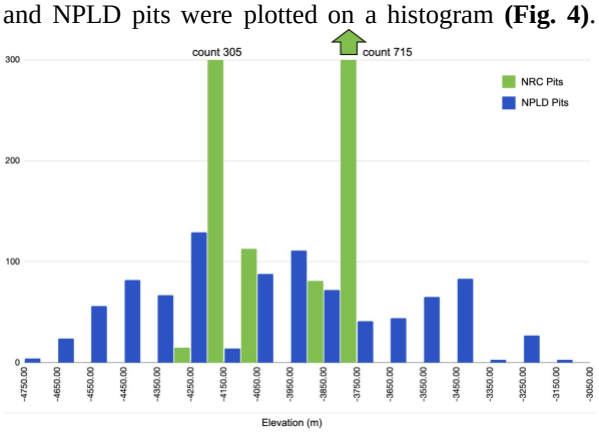

Figure 4. Histogram of the elevations of individual pits in the NPLD and NRC. Elevation bins are 100 meters.

The NRC pits were found at elevations between -4180 m and -3828 m, while pits found in troughs do not appear to display a strong elevation trend. NRC pits represent three locations of possible fault-related pits **(Fig. 3)**.

Conclusions: We mapped >2,000 pits throughout the NPLD and on the NRC. With this larger sampling of pit locations, we are now able to investigate whether the pits lie along certain layers throughout the NPLD, if the pits are preferentially found on equator-facing slopes or pole-facing slopes, potential minimum depths of the pits, and when the pits formed or if they are actively forming. A more complete inventory of the pit locations and distribution throughout the NPLD will help shed light on the pits' formation. Currently, we are analyzing a time series of HiRISE images acquired over multiple Mars Years and seasons to help understand the temporal evolution of the pits.

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References: [1] Mattson S. et al. (2014) *LPSC XLV*, Abstract #243. [2] Tanaka, K.L. et al. (2008) *Icarus*, *196*, 318-358. [3] Landis, M.E. et al. (2023) *Icarus*, *419*, 115794. [4] McEwen, A. S. et al. (2007) *JGR*, *112-E5*, E05S02. [5] Sutton, S. et al. (2017) *LPSC XLVIII*, Abstract #2592. [6] Smith, D.E. et al. (2001) *JGR*, *106*, 23689.

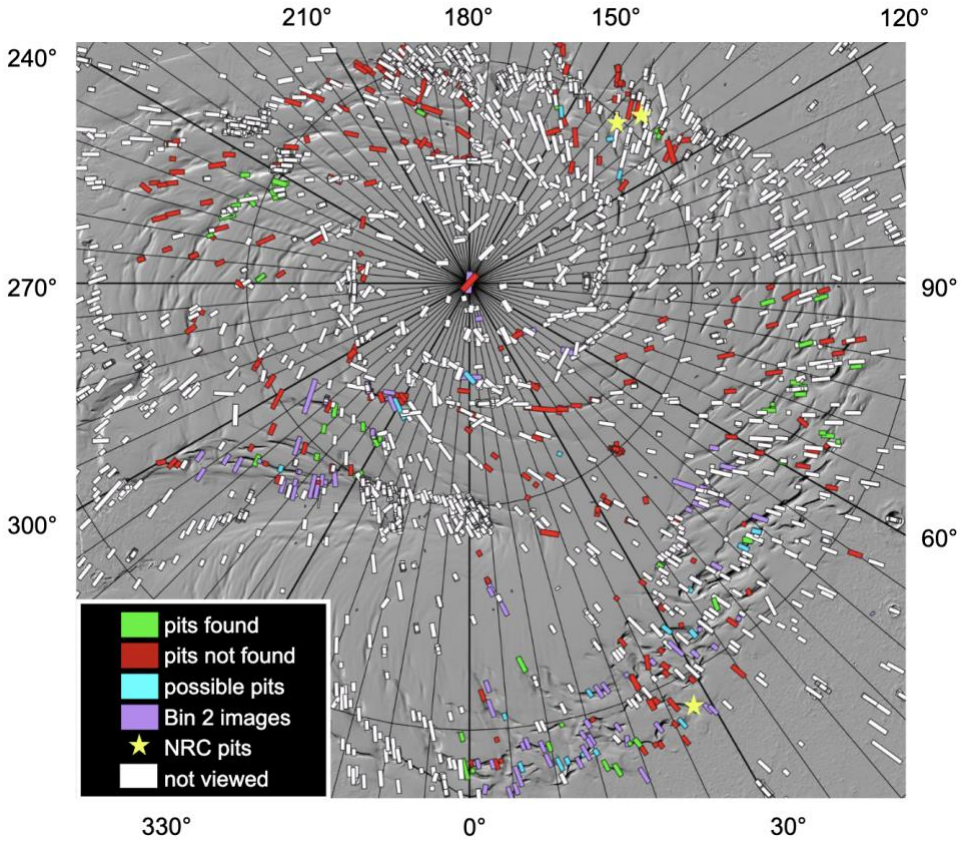

Figure 3. Map of HiRISE image footprints on MOLA shaded relief of the north polar region of Mars.