INTERPRETING THERMAL PROPERTY VARIATIONS IN THE SOUTH POLAR LAYERED DEPOSITS, MARS.

S. F. A. Cartwright[1], J. García-Cajiao[2], M. E. Landis[1], and J. L. Whitten[2], [1]Laboratory for Atm. & Space Physics, Univ. of Colorado Boulder, samuel.cartwright@colorado.edu [2]Tulane Univ., Dept. of Earth & Env. Sciences.

Introduction: The South Polar Layered Deposits (SPLD) comprise a ~4 km-thick dome of interbedded water ice and dust that is thought to preserve an extensive record of Mars climate history [1]. Close investigation of the SPLD has therefore been of great interest to those studying the dynamics of Mars's climate and how it has changed over time [e.g., 2, 3]. However, to decipher this climate record, it is first necessary to understand the geologic context and history of the SPLD through a sufficiently detailed geologic map. To fill gaps in understanding left by existing maps [e.g., 4, 5], we are compiling a new 1:2M scale geologic map of the south polar region below 70º S that can serve as a fundamental reference for future investigations of the SPLD and surrounding terrains. In an accompanying abstract [6], we present the results of preliminary mapping in an initial region of interest (ROI, Fig. 1). Here we discuss insights into how our basemap should be interpreted in combination with other datasets to delineate meaningful geologic units and surface modifications.

THEMIS basemaps: Many contemporary geologic maps of Mars are made using a reference basemap produced by [7] from Thermal Emission Imaging System (THEMIS)[8] data. At 100 m/pixel, these geodetically controlled products offer an unmatched combination of detail and accuracy compared to other datasets. The mosaics are also notable in that variations in brightness are directly influenced by the thermal properties of the surface because the constituent THEMIS data capture daytime radiance in the thermal infrared (IR). This is unlike other datasets in which brightness variations reflect albedo differences at visible wavelengths. THEMIS mosaics are therefore effective basemaps for dividing units because thermal differences from variable illimitation show morphology clearly. However, it is important to keep in mind that thermophysical properties of surface materials (e.g., composition) are also reflected in THEMIS brightness.

The controlled THEMIS mosaics produced by [7] do not extend to the polar regions of Mars due to intra-annual changes in seasonal CO_2 frost cover [9]. For our map we use uncontrolled mosaics produced by [10], which are also constructed from THEMIS daytime IR data, but with manual editing of the mosaic roster to remove image strips with apparent seasonal frost cover. It is also important to note that the diurnal skin depth measured by THEMIS in ice-cemented soil and water ice is ~20 cm and ~5–6 m, respectively [11]. We observed multiple areas with distinctive THEMIS expression in the south polar basemap. For example, the region of interest mapped in [6] displays brightness variations at small and large scales with patterned or textured appearances (Fig. 1).

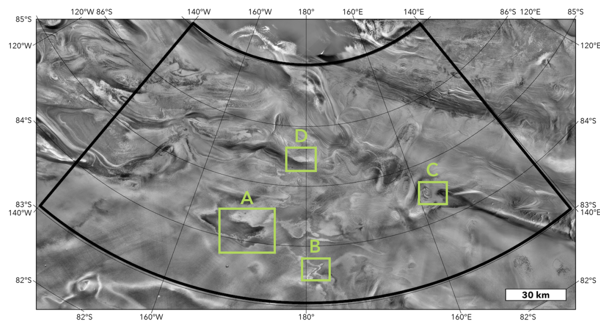

Figure 1. THEMIS Daytime IR basemap used in the new geologic map. The extent of the initial mapping ROI [6] is shown in black while green boxes delineate examples of brightness variation discussed in Fig. 2.

Other basemaps: To better understand how variations measured by THEMIS should be interpreted in terms of geologic units and surface modification in the SPLD, we compared the mosaic basemap to other orbital datasets. This includes a hillshade derived from Mars Orbiter Laser Altimeter (MOLA)[12] data, which provides a detailed view of surface morphology at 512 pixels/degree (~115 m/pixel) over much of the SPLD.

For higher resolution views of surface texture, morphology, and albedo, we use images from the Context Camera (CTX, 5 m/pixel)[13] and High Resolution Imaging Science Experiment (HiRISE, ~25 m/pixel)[14]. While there have been recent efforts to make regional mosaics from CTX data [15, 16], they do not provide adequate seasonal control, so we used individual image strips not obscured by CO_2 frost cover.

Observations & Discussion: Some of the highest contrast variations in THEMIS brightness are observed in the bottom center of the initial mapping ROI (Fig. 2A). Here MOLA topography shows an elevated plateau with rough edges that matches the extent of very dark material in the THEMIS basemap. The regions of light and dark observed in THEMIS are inverted in CTX albedo (e.g., bright in THEMIS is dark in CTX) while HiRISE shows differences in surface texture between these regions (e.g., the dark plateau is rougher than surrounding bright material). These surface characteristics in the four datasets are also found in another location where MOLA shows stair-stepped plateaus (Fig. 2B). Together these examples suggest that dark areas show consolidated SPLD material and bright areas trace unconsolidated dust/sand that has accumulated around the edges of eroded plateaus, possibly representing coherent layers of the SPLD. Notably, the margins of these regions are consistent across datasets.

However, other locations in the ROI do not fit this picture. For example, concentric rings of dark material are observed around a topographic dome (Fig. 2C), but there are no albedo variations associated with them in CTX. Additionally, the only location in the ROI with a dune field (Fig. 2D) does not display distinct brightness in THEMIS compared to surrounding exposures and actually has a lower relative brightness than other areas (e.g., Fig. 2A,B). These examples suggest that brightness variation in THEMIS has a complex relationship to thermal properties and topographic features on the surface that go beyond distinguishing consolidated/unconsolidated material. For example, intermediate brightness in THEMIS may represent unique SPLD properties or simply variations in the thickness or other characteristics of dust mantling.

Preliminary Conclusions: Brightness variations in the THEMIS basemap are likely linked to differences in thermal properties between consolidated SPLD material and unconsolidated dust/sand mantling. However, observed variations or relative brightnesses are not diagnostic of surface features and should not be used alone to delineate geologic units. Instead, it is critical to compare THEMIS brightness to other datasets and gather as much context as possible. These observations do suggest that the SPLD surface has experienced processes that sculpt topography and produce local (<1 km-scale) variations in thermal properties.

Acknowledgments: This work is supported by NASA PDART 80NSSC21K0882.

References: [1] Byrne S. (2009) *Annual Rev. of Earth & Plan. Sci.*, *37*(1), 535–560. [2] Smith I. B. et al. (2016) *Science*, *352*(6289), 1075–1078. [3] Becerra P. et al. (2019) *GRL*, *46*(13), 7268–7277. [4] Tanaka K. L. & Scott D. H. (1987) USGS I–1802–C. [5] Tanaka K. L. et al. (2014) USGS SIM 3292. [6] García-Cajiao J. et al. (2023) LSPC 53, Abs. #2991. [7] Fergason R. L. & Weller L. (2019) 4th Plan. Data Workshop, Abs. #7059. [8] Christensen P. R. et al. (2004) *Space Sci. Rev.*, *110*(1), 85–130. [9] Piqueux S. et al. (2015) *Icarus, 251*, 164–180. [10] Edwards C. S. et al. (2011) *JGR*, *116*(E10). [11] Landis M. E. & Whitten J. L. (2022) *GRL*, *49*(10), e2022GL098724. [12] Zuber M. T. et al. (1992) *JGR*, *97*(E5), 7781–7797. [13] Malin M.C. et al. (2007) *JGR, 112*(E5), E05S04. [14] McEwen A. S. et al. (2007) *JGR, 112*(E5), E05S02. [15] Dickson J. L. et al. (2018) LPSC 49, Abs. #2480. [16] Robbins S. J. et al. (2020) *ESS, 7*(10), e2019EA001054.

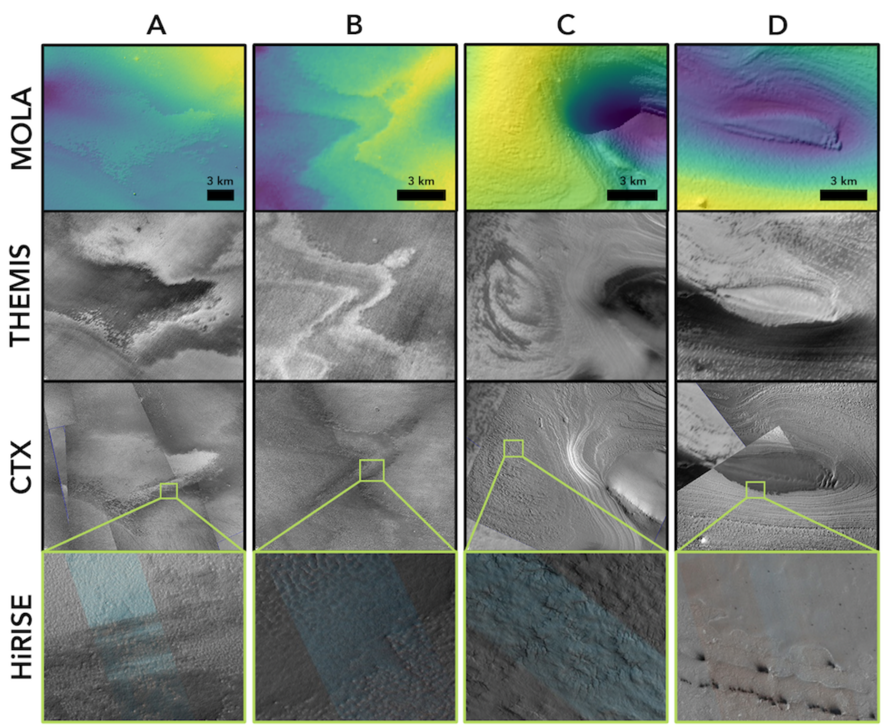

Figure 2. Four example regions displaying distinct brightness variation in the THEMIS Daytime IR basemap. Additional context of surface properties is given by a MOLA hillshade (3× VE, purple=low, yellow=high), CTX, and an inset detail of HiRISE image data. See Fig. 1 for panel locations.