TOPOGRAPHIC TESTS OF LIQUID WATER AT THE SOUTH POLE OF MARS. Imani T. Lawrence, Michael M. Sori, and Kristel Izquierdo, Purdue University, West Lafayette, IN 47906 (ilawren@purdue.edu, msori@purdue.edu, kig@purdue.edu)

Introduction: The high basal reflectivity of the area centered at $193^\circ\,E\ 81^\circ\,S$ in the South Polar Layered Deposits (SPLD) of Mars was hypothesized to be consistent with the presence of liquid water [1]. The reflectivity of the area was measured by the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) in 2018. This high-reflectivity, 20 km wide region was thought to contain liquid water under the 1.7-km-thick ice layer, however, it was also argued that features other than liquid water could be responsible for the high reflectivity, such as salty ice and clay due to their high electrical conductivity [3–5].

One way to test whether liquid water exists in this region at the base of the SPLD is to look at the SPLD surface topography. Theoretically, depressions in surface topography could be caused by latent subglacial water bodies. This was inferred because water potentially part of subglacial hydrological systems could, under some conditions, experience drainage events and produce features on the surface in the form of topographic depressions [2]. On Mars, these depressions could have surface topography of approximately meters [2].

We hypothesized that, if liquid water exists under the SPLD, it could cause an observable topographic feature at the surface. Following this hypothesis, we investigated the SPLD surface topography to test if there were significant vertical depressions in the area surrounding $193^\circ\,E\ 81^\circ\,S$ caused by melting of ice into water at the base [2].

Methods: We used JMARS, a geospatial software, to investigate the elevation of the SPLD in two different ways. First, we used an interpolated topographic map at a resolution of 512 pixels per degree with the Mars Orbiter Laser Altimeter (MOLA) topography dataset. From this we recreated the triangular-shaped area encapsulating the highly reflective area, $193^\circ\,E\ 81^\circ\,S$[1], and extracted topographic MOLA profiles going through this. We then used MATLAB, extracting the best fit line from the data to make a horizontal version of the profile in order to remove the long-wavelength slope in the data. We analyzed the modified profiles of elevation versus distance to determine if there were topographic depressions in the bright reflection area. We took the mean and standard deviation of the modified data to compare the outside regions of the area to the area inside the triangle.

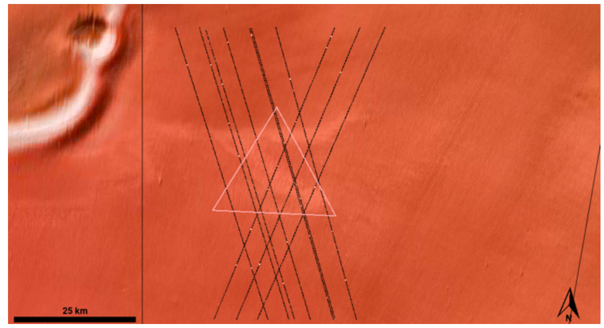

Figure 1. Individual MOLA tracks (black lines) through the region in the SPLD where subsurface liquid water was proposed to be at. The pink line approximately represents the ~20-km-wide area where liquid water is hypothesized to exist at the base of the SPLD [1].

The MOLA data mentioned in the previous paragraph was interpolated, so it may contain complicating effects of the deposition and sublimation of seasonal ice. Therefore, we also use individual MOLA tracks to look for topography lows near the same high-reflectivity area. On JMARS, we used the same margins for the triangle we used for the interpolated profiles and added a new layer, MOLA Shots. Using the same process, we exported 10 profiles of individual MOLA tracks (Figure 1). As before, we removed a best fit line from each profile, and then calculated the mean and standard deviation of the elevation inside and outside the triangular region proposed to have liquid water.

Results: Figure 2 shows a preliminary result of one of the profiles, that had higher elevation inside the region in comparison to the areas outside. The average elevation of this profile within the region was 4.02 m, while the outside regions had lower average elevations of -0.83 m and -1.51 m.

The other nine graphs of the profiles follow a similar pattern of having greater average elevation within the region, ranging between 1.95 m to 6.65 m, while the outside regions had an average elevation between -2.02 m and 0.25 m as shown in Table 1. Overall, the trend is that the region inside the triangle has higher elevation than the regions outside of the triangle.

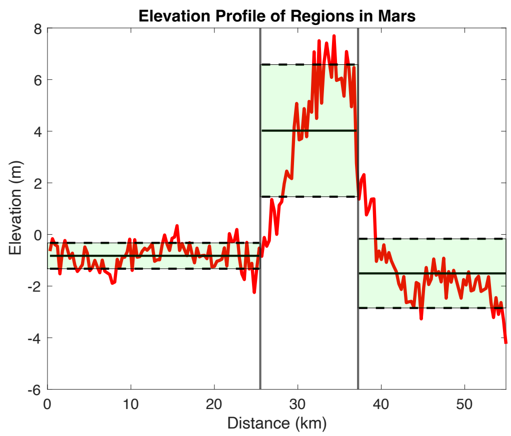

Figure 2. Horizontal plot of elevation (m) versus distance (km) of the region of interest on Mars for one sample MOLA track. The central portion in between the two vertical lines approximates the region of bright MARSIS reflectors. This MOLA track shows a higher elevation within the region. The solid horizontal line represents the mean elevations, while the dashed lines show one standard deviation of the elevation.

Profile	Average Elevation inside the region (m)	Average Elevation Outside 1 (m)	Average Elevation Outside 2 (m)
1	3.88	-0.91	-0.91
2	2.01	-0.94	-1.29
3	5.27	-0.57	-0.62
4	4.00	-1.13	0.25
5	2.12	-0.61	-2.03
6	3.45	-0.75	-0.62
7	4.02	-0.83	-1.51
8	4.31	-0.86	-0.89
9	6.65	-0.55	-1.30
10	1.95	-1.00	-1.09

Table 1. Average elevation the region of each profile in comparison to the outside regions shows an average higher elevation within.

Discussion: Our preliminary work suggests that the region of bright basal reflectance might correspond to a local topographic high. If this results holds in further tests, it implies that any water at the base of the SPLD is not part of a larger hydrological system that experiences drainage events and topographic collapse as might be predicted by subglacial hydraulic theory under some conditions [2]. We are not aware of a reason why the alternative hypotheses for the bright MARSIS reflectors, such as clays [4] or materials with high electrical conductivity [3] contained at the base the ice in the SPLD, would lead to topographic highs. It could be that the putative topographic high is unrelated to basal reflectors.

One way in which a topographic high might be indirectly related to basal reflectivity is through thermal expansion of ice. If the areas of high basal reflectivity do represent liquid water, it may be because that isolated location is anomalously hot [6]. In this case, the ice column above the water would be warmer, on average, than a normal ice column in the SPLD. The thermal expansion of the ice would be of order meters, which could be consistent with observations.

Ongoing and Future Work: We analyzed the topography of the 20-km-wide high-reflectivity area of the SPLD of Mars taking individual profiles to look for vertical depressions. In ongoing work, we will quantitatively correlate modified topography profiles from individual MOLA tracks with MARSIS basal reflectivity, instead of solely approximating the high reflectivity region in a triangular shape. Also, other authors [7] have proposed that there may be a lot of areas with high basal echo power all over the SPLD, so we will repeat our analysis in some of those areas.

References: [1] Orosei et al. (2018), Science 361. [2] Arnold et al. (2019), JGR Planets 124. [3] Bierson et al. (2021), Geophysical Research Letters 48. [4] Smith et al. (2021), Geophysical Research Letters 48. [5] Schroeder and Steinbrügge (2021), Geophysical Research Letters 48. [6] Sori and Bramson (2019), Geophysical Research Letters 46. [7] Khuller and Plaut (2021), Geophysical Research Letters 48.