EVALUATING THE STRUCTURE OF THE SOUTH POLAR LAYERED DEPOSITS ON MARS USING SHARAD DATA.

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Introduction: Polar layered deposits on Mars are composed of fine layers of ice and dust that record climate variations. The layering in the northern ice cap is easily observed in data from the Shallow Radar (SHARAD) instrument and can be traced through the entire cap [1]. The South Polar Layered Deposits (SPLD) also contain finely layered deposits, as evidenced by visible images of scarp walls [2]. However, this layering in the SPLD has not been detected throughout the deposit with SHARAD data. Distinct layer groups or packets have only been observed in certain regions of the SPLD, such as Promethei Lingula [e.g., 3, 4].

From the visible images it was proposed that the SPLD has a domical layered structure that is continuous throughout the deposit, similar to the NPLD. Three different layer sequences were observed (from bottom to the top: the Inferred Layer (IL), Promethei Lingula Layer (PLL), and the Bench Forming Layer (BFL) sequences [2]). The BFL and PLL were identified by distinct patterns of outcropping layers. In the BFL sequence there are four erosion-resistant layers with morphology suggestive of a higher dust content [5].

Here we propose to test this proposed domical structure for the SPLD, as the structure of the polar caps has important implications for the climate history of Mars. Using SHARAD data we measure how far the radar signal penetrates through the SPLD, searching for the interfaces between the three major layer sequences.

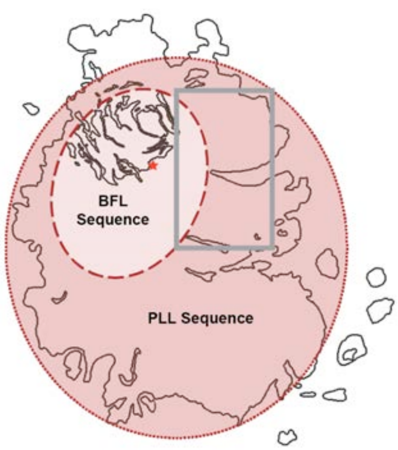

Figure 1. Schematic of the South Pole Layered Deposits (SPLD; black outline) with the proposed extents of the BFL (red dashed line) and PLL (red dotted line) layer sequences [2]. The study area is outlined by a grey box (see Figure 2).

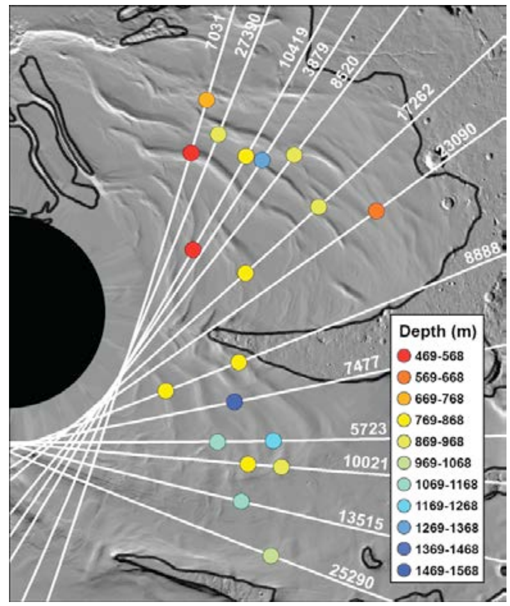

Figure 2. Study region within the South Pole Layered Deposits (SPLD; black outline) overlain by SHARAD tracks (white lines, labeled with track number). Colored circles indicate the location of depth measurements on the radargrams; color indicates the depth of the deepest observed layer. Warm colors indicate shallow layer depths and cooler colors represent deeper detected layers. MOLA hillshade 128 ppd basemap.

Methodology: For this analysis we use Shallow Radar (SHARAD) subsurface sounding data to search for the boundary between the three proposed packets of layers (i.e., BFL, PLL, IL [2]) in the SPLD. The SHARAD radargrams are useful for extrapolating the extent of layers observed along scarp faces, in troughs, and along the periphery of the SPLD. Here we analyze 13 different SHARAD tracks that cover the SPLD between 41°E and 132°E, overlapping the buried portion of the Promethei Basin (Fig. 2).

The 13 selected tracks were analyzed to determine the depth of the deepest visible layers in order to determine whether the boundary between the proposed layer sequences is evident (Fig. 2). In addition, the radargrams are analyzed to search for reflections that could represent either (1) boundaries between layer sequences or (2) bench-forming layers in the BFL sequence that also have significant differences in material properties (e.g., density differences leading to dielectric contrasts) [e.g., 2, 5].

Results: The distribution of maximum observed radar-interface depths varies from ~470 m to ~1470 m, assuming a dielectric constant for ice of 3.15 [1] (Fig.

2). In general, the radar signal penetrates deeper in Promethei Lingula (Fig. 2, bottom lobe) compared with Australe Ligula (Fig. 2, top lobe). Clear internal layering is only visible in the exterior regions of the SPLD; the further from the pole the deeper the radar signal is able to penetrate. Along several tracks (e.g., 10419, 17262, 5723) the deepest observed layer increases in depth with radial distance from the pole (Fig. 2). The lack of a clear signal in the interior of the SPLD has been attributed to a diffuse echo, referred to as "fog", that begins at the deposit surface and persists throughout (and perhaps beyond) the entire time-delay extent of the SPLD [6, 7].

Discussion: Rough estimates for the thicknesses of the three different layer sequences are made based on outcrop elevations and thicknesses of regional deposits of certain layers (i.e., the thickness of the Promethei Lingula deposits is used as an approximate estimate of the PLL sequence). The BFL sequence is the thinnest of the three sequences, having a thickness on the order of several hundred meters and proposed to extend over only a portion of the SPLD (Fig. 1). The most distinct layer in visible imagery (BFL_3) is estimated to occur ~230 m below the highest point of the SPLD and gradually approach the surface with decreasing latitude [5]. The PLL sequence is expected to occur throughout the SPLD and the IL sequence is expected to occur over a smaller area, similar to the extent of the BFL (Fig. 1). Based on observations at Promethei Lingula, the PLL sequence is expected to be on the order of 1–2 km. As a result, the IL is expected to be ~0.5–1.5 km thick. Unfortunately, the SHARAD signal does not penetrate to depths corresponding to the IL sequence in the 13 tracks analyzed thus far. We continue to search the data for evidence of the IL upper boundary.

The abovementioned sequence thicknesses were plotted on a radargram to search for any indication of layering at the expected depths (Fig. 3). The PLL sequence of layers is clearly evident on the right hand side of the radargram, but the layering quickly disappears into the "fog" at higher latitudes. Truncated layers are visible at the top of the PLL sequence, indicating this sequence was eroded prior to deposition of the BFL sequence, or is currently being eroded [8].

The proposed extent of the BFL (Fig. 1) and where the layering is expected to occur (red line) and to intersect the surface (top white bracket) is indicated in Figure 3. There are faint hints of layering visible in the region where the BFL sequence is expected, but no clear layering is observed in that part of the SPLD. The "fog" has obscured the radar signal at these higher latitudes, preventing identification of layers and/or layer boundaries.

Future work involves investigating more SHARAD tracks around the periphery of the expected outcrop location of the BFL sequence. In addition, other analysis and incoherent summing [e.g., 7] will be employed to search for layering and sequence boundaries in the highest latitudes of the SPLD.

References: [1] Putzig N. E. et al. (2009) *Icarus, 204*, 443–457. [2] Milkovich S. M. and Plaut J. J. (2008) *JGR, 113,* E06007. [3] Seu R. et al. (2007) *Science, 317*, 1715–1718. [4] Milkovich S. M. et al. (2009) *JGR, 114*, E03002. [5] Byrne S. and Ivanov A. B. (2004) *JGR, 109*, E11001. [6] Campbell B. A. et al. (2014) *8th Mars,* Abstract #1350. [7] Campbell B. A. et al. (2015) *LPSC XXXXVI,* Abstract #2366. [8] Smith I. B. et al. (2015) *Geomorph., 240*, 54–69.

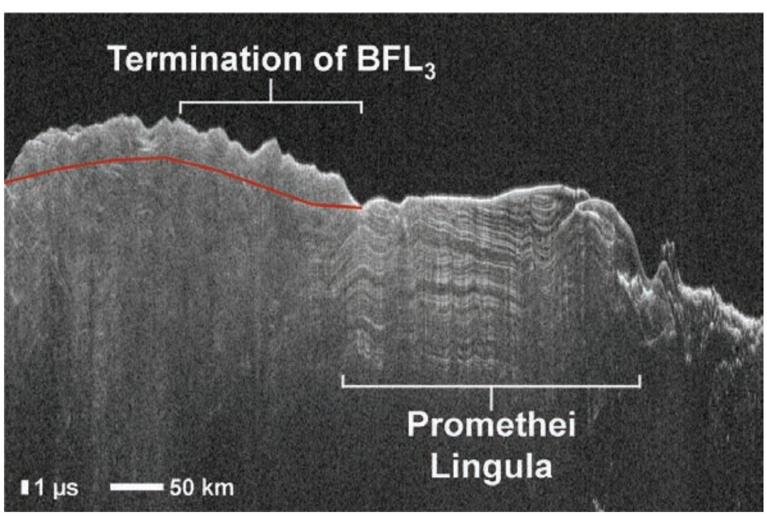

Figure 3. Section of a radargram from track 10021 corresponding to the section of the track shown in Figure 2. Red line denotes a layer ~230 m below the surface, which corresponds to the expected location of BFL_3. The PLL sequence is visible in the region labeled Promethei Lingula.