LOCAL AND REGIONAL STRATIGRAPHY OF THE SOUTH POLAR LAYERED DEPOSITS OF MARS IN RADAR. S. M. Milkovich[1], J. J. Plaut[1], A. Safaeinili[1], R. J. Phillips[2], R. Seu[3], G. Picardi[3]. [1]Jet Propulsion Laboratory, California Institute of Technology, M/S 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109, Sarah.M.Milkovich@jpl.nasa.gov; [2]Southwest Research Institute, Boulder, CO, 80302; [3]INFOCOM Department, University of Rome "La Sapienza," 00184 Rome, Italy.

Introduction: The south polar layered deposits (SPLD) are exposed on the walls of troughs and scarps within the south polar deposits of Mars. The details of the formation process of the layers remains unknown; the stratigraphic record and the internal structure of the SPLD can provide clues to these processes. There is evidence for locally continuous layers in regions around the deposit [1, 2, 3] and a dome-shaped internal structure rather than horizontal layers [1, 3]. Two sounding radar instruments are collecting information about the subsurface of the SPLD. Both MARSIS, the radar onboard Mars Express (operating at 1.8-5 MHz, [4]) and SHARAD, the radar onboard Mars Reconnaissance Orbiter (operating at 20 MHz, [5]), detect subsurface reflections at multiple depths within the SPLD in several locations.

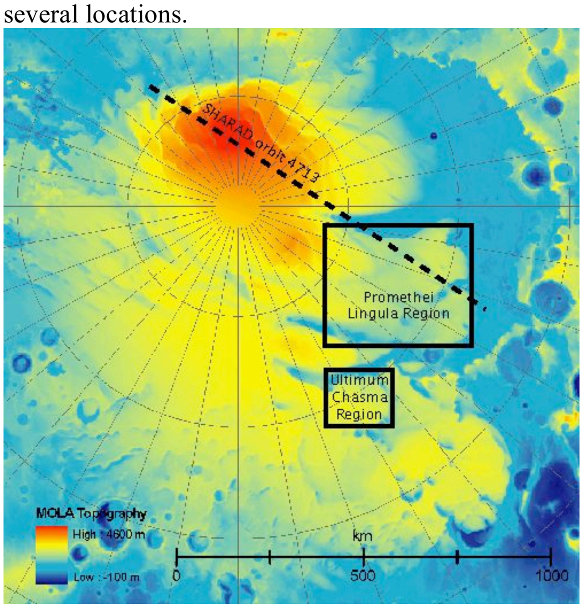

Figure 1. Topography of the SPLD. Boxes indicate the locations of the Promethei Lingula and Ultimum Chasma regions under study. Dashed line indicates the path of SHARAD orbit 4713.

In this study, we examine the local stratigraphy in two areas (Figure 1) in the radar datasets and attempting to correlate the layers in the visual images with the reflections in the radar. We also examine the regional stratigraphy of the SPLD and compare our observations of the internal structure of the deposits with previous image-based stratigraphic analysis. We calculate elevation measurements assuming pure ice, consistent with the strength of the basal reflection observed by MARSIS [4]. Since the distances scale by the inverse of the square root of the dielectric constant, small variations in material (i.e., dust content) are not likely to have a profound effect on the elevations calculated here.

Promethei Lingula. MARSIS observes up to three strong internal reflections, plus a strong basal reflection at approximately 1.2 – 1.5 km depth in the Promethei Lingula (90˚-140˚E) region of the SPLD (Figure 1). Reflections where orbits cross are at the same elevations in each radargram (< 100 m, or the resolution of the data) and the reflections in the remaining orbits are at similar elevations; we therefore conclude that the same reflectors are being observed in each orbit. SHARAD detects many tens of reflections with several packets of multiple reflections separated by non-reflective regions with depth; the lowest reflection is observed intermittently at ~ 1 km depth [5, 6]. Comparisons of neighboring and crossing orbits indicate that MARSIS reflections correlate to the boundaries of packets of reflections in the SHARAD data; whatever change in composition of the SPLD that causes the SHARAD reflections to occur in packets may also be the source of the MARSIS reflections. By comparing crossing orbits and using stratigraphic correlations between orbits, a three dimensional picture of the internal structure of the SPLD as observed by SHARAD can be assembled. Reflections extend many hundreds of km throughout the Promethei Lingula region, and generally decrease in elevation towards the margins.

Comparisons of SHARAD reflections that intersect with the surface and THEMIS and MOC images indicate that an individual reflection may correlate to multiple (3-7) layers at MOC resolutions (~ 6 m/pxl). The layers in this region are eroding in groups, resulting in a stair-stepped topographic profile; the underlying physical properties of the layers causing this erosional behavior may also be the cause of a radar reflection. By fitting a surface to correlated reflections in multiple orbits using an inverse distance weighting technique and extrapolating that surface to the wall of Chasma Australe, it is possible compare the elevations of the reflectors to the sequence of layers exposed on the wall in THEMIS images. Preliminary results indicate that three major reflectors correlate with changes in layering styles within the SPLD. In particular, a sequence of dark, thin layers near the bottom of the layer stratigraphy in this region may correlate to a single reflection. A shift in layering style between a region where individual layers tend to be subtle and hard to distinguish and a region of thicker (~ 40 m), bright, erosion-resistant layers may correlate to another reflection.

Ultimum Chasma: Additional subsurface reflections are observed in both MARSIS and SHARAD datasets in a portion of the SPLD located near the eastern wall of Ultimum Chasma (Figure 1). Three internal reflections are observed in the MARSIS data. Many tens of reflections are observed in the SHARAD data, although none of these reflections intersect with the surface; indeed the shallowest are located about 100 m below the surface. Similar analyses to those carried out at Promethei Lingula are underway. Preliminary results indicate that some correlation between MARSIS and SHARAD is possible in this region as well.

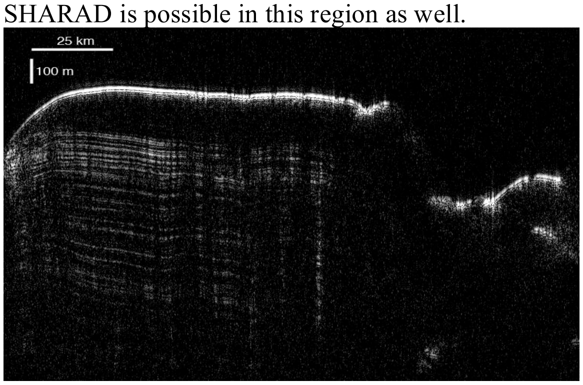

Figure 2. SHARAD orbit 2939 displays subsurface reflections within the Ultimum Chasma region. The vertical scalebar is calculated using pure ice.

Regional SPLD Stratigraphy. Figure 3 shows SHARAD orbit 4713 corrected for pure ice. The location of this orbit can be found in Figure 1. The left portion of the SPLD is located in the Promethei Lingula region while the right portion is the main body of the deposit; the flat region separating the two is the floor of Chasma Australe. Multiple subsurface reflections are seen in both regions; while those in Promethei Lingula are located directly below the surface, those in the main deposit are several hundred m below the surface. This separates the main body of the SPLD into two zones, one containing no reflections (marked A in Figure 3) and one containing multiple reflections (marked B in Fig. 3). The SHARAD signal is attenuated several km below the surface. MARSIS penetrates through the entire stack of SPLD and observes a strong basal reflection across a majority of the deposit [4].

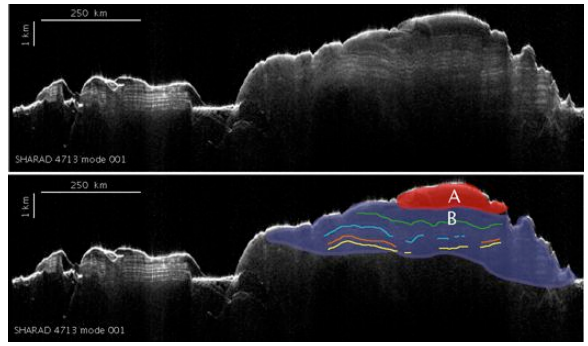

Figure 3. Upper: SHARAD orbit 4217, corrected for pure ice. Lower: Red zone A contains non-reflective SPLD purple zone B contains reflective SPLD. Other lines trace major individual reflectors in the main body of the deposit.

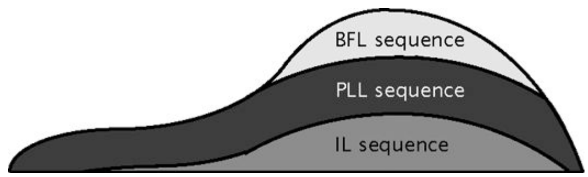

Figure 4. Sketch of the internal structure of the SPLD proposed by [3] based on image stratigraphy. The Bench Forming Layers (BFL) and Promethei Lingula (PLL) sequences have been directly observed within images, while the Inferred Layers (IL) sequence is inferred to exist due to the thickness of the SPLD in the central regions of the deposit.

Recently, Milkovich and Plaut [3] divided the SPLD into three sequences based on stratigraphic analysis of THEMIS visible (17 m/pxl) images. A sketch of the distribution of these sequences and the internal structure of the SPLD is in Figure 4. The uppermost sequence, termed the Bench Forming Layer (BFL) sequence, is found only near the residual ice sheet. The layer sequence exposed in the Promethei Lingula region, however, is also identified in multiple locations below the BFL sequence and is thought to be higher in elevation towards the center of the deposit rather than horizontal. It is possible that these sequences correspond to the sequences observed in the radar. Further analysis is underway.

Summary. Reflections within the Promethei Lingula region correlate to groups of layers as observed in images. Analysis is underway to determine if this is true in a neighboring region of SPLD. Initial analysis of SHARAD data from the main body of the SPLD indicates two distinct units within the upper several km, consistent with the image-based stratigraphic analysis of [3].

References: [1] S. Byrne, A. Ivanov (2004) *JGR 109*, 10.1029/2004JE002267. [2] E. Kolb, K. Tanaka (2006) *Mars 2*, doi:10.1555/mars.2006.0001. [3] S. Milkovich, J. Plaut (2008) JGR in press. [4] J. Plaut et al (2007) *Science* 316, 92-95. [5] R. Seu et al (2007) *Science* 317, 1715. [6] Milkovich et al, (2008) Fall AGU meeting.