CHARACTERISTICS OF THE BASAL INTERFACE OF THE MARTIAN SOUTH POLAR LAYERED DEPOSITS.

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Introduction: The South Polar Layered Deposits (SPLD) are several kilometer-thick stacks of layered H_2O ice deposits extending outward from the martian south pole. The layers within the SPLD are thought to be caused by variations in H_2O ice and dust content potentially linked to changes in Mars' obliquity and orbital eccentricity [1]. Thus, the SPLD are a unique landform which may hold millions of years of Mars' recent climatic history within its layers.

[2] used subsurface radar sounding data from the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) to map the basal interface of the SPLD, measure the thickness and volume of the SPLD, and characterize the electrical properties of these deposits.

Here we build on this previous work by making use of the wealth of data acquired by MARSIS since 2005 over the south pole to improve the derived characteristics of the SPLD basal interface.

Methods: MARSIS operates simultaneously at 2 of 4 frequency bands (1.8, 3.0, 4.0 and 5.0 MHz) with a 1 MHz bandwidth [3]. In this work, we use a compiled south polar data set, consisting of over 2000 orbits, taken in the 3 higher frequency bands (3, 4 and 5 MHz) to generate a 3D radar imaging volume [4, 5].

Key features of this 3D radar imaging volume are: (1) voxel (volume pixel) dimensions 1.5 km x 1.5 km (horizontal) x 50 m (depth), (2) depth correction is applied in the subsurface using a wave speed in pure water ice (real dielectric constant $\varepsilon = 3.1$), (3) overlapping echo frames from different orbits are averaged, (4) empty voxels are filled with horizontally applied nearest neighbor interpolation, and (5) slices are extracted for all vertical and horizontal planes in each volume for individual study and animations [4, 5].

By assuming that the wave speed is equal to that in pure water ice, reflectors are repositioned in an approximately correct geometry to facilitate identification of interfaces. In areas known to contain lenses of CO_2 ice [6], some distortions in reflector position can occur. However, this effect is evident in only a small fraction of the 3D volume.

We annotated subsurface (basal) interface reflectors for all slices where it was discernible in the volume. The thickness of the basal interface can vary slightly, but all annotations were made manually and are typically 2 - 3 pixels thick (equivalent to 100 – 150 m uncertainty in depth). In some cases, multiple subsurface interfaces appear to be present, which were distinguished based on their elevation, context and relative brightness in each slice.

The elevation of each detected subsurface interface relative to the MOLA reference ellipsoid was extracted, using the water ice depth correction. Then, the elevation of the MOLA surface overlying each subsurface interface was extracted to find the thickness of the SPLD at each point.

Results and Discussion: About 44, 000 points representing the SPLD basal interface were obtained (Fig. 1), representing a 25x improvement over previous work [2]. The majority of the basal interface detections lie at elevations 3-4 km above the reference ellipsoid. However, unusually low elevation detections are present in Ultimi Lingula (which also contains high elevation detections), and within some craters. Note that we have omitted the unusually deep depressions in the near-polar region previously mapped by [2] because their regional context suggests that they represent a distinct unit that lies below the base of the SPLD.

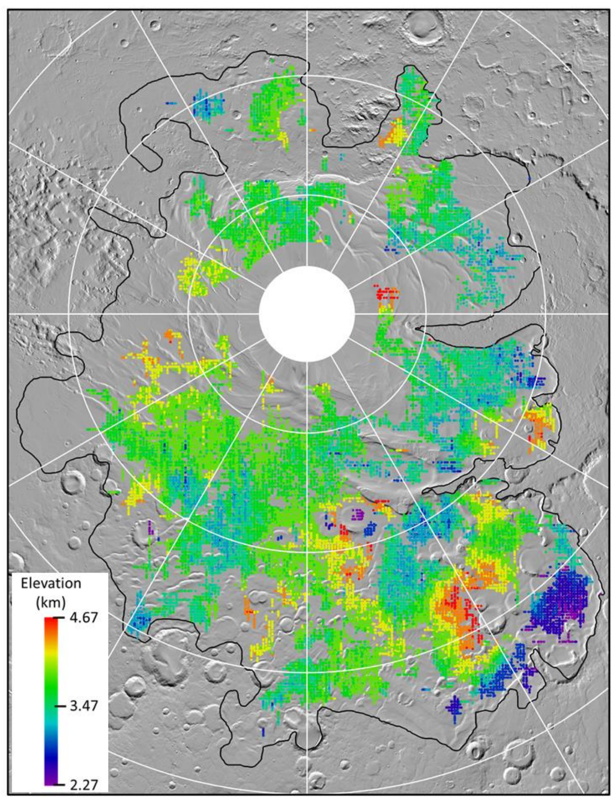

Figure 1. *Topography of the SPLD basal interface based on MARSIS measurements. The SPLD unit boundary is outlined in black.*

The resultant interpolated map of SPLD thickness is shown in Figure 2. The thickest portions of the SPLD (~3.7 km) lie below the residual polar cap, whereas regions of moderate thickness 1.5-2.0 km) are distributed throughout the interior SPLD. With the exception of the unusually thick Ultimi lobe, most of the distal SPLD areas are < 1 km thick.

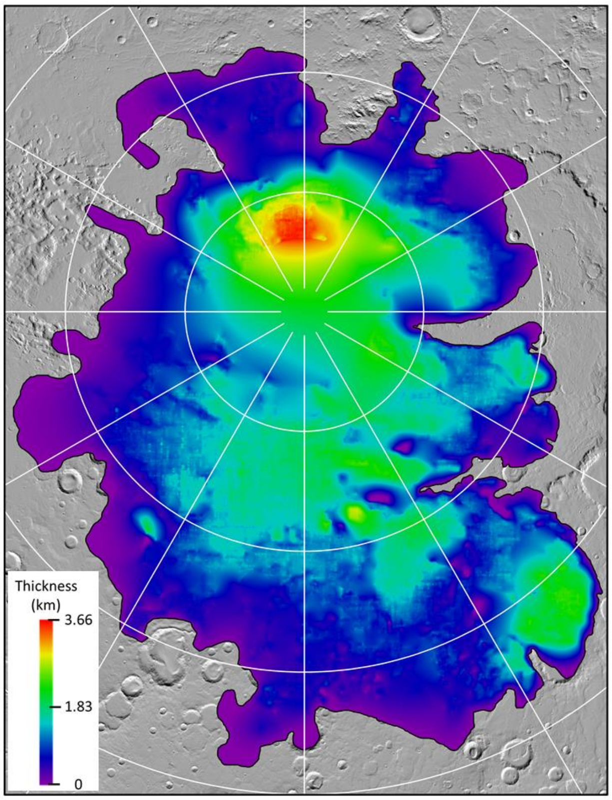

Figure 2. *Thickness of the SPLD, based on interpolated MARSIS measurements and MOLA surface topography.*

The calculated volume of the SPLD is ~1.6 × 10^6 km^3, consistent with previous mapping efforts, resulting in a global equivalent water layer thickness of ~11 m [2].

For all detections, the relative reflected radar power of the surface and basal interface at each frequency were extracted. Figure 3 shows a 2D histogram of the 4 MHz basal interface reflected power relative to that of the average SPLD surface, versus SPLD thickness. There is a dense concentration of values centered around ~1.5 km (warmer colors in Fig. 3 and green regions in Fig. 2). A secondary cloud of points displays high relative power at large thicknesses, corresponding mostly to the thick near-polar regions. Particularly interesting are locations where the basal interface power exceeds the surface power (positive values in Fig. 3). This relationship, while not expected for transmission through lossy materials, occurs widely under the SPLD, including the areas noted by [6,7] and proposed to be evidence for evidence for a liquid water component at the base of the SPLD.

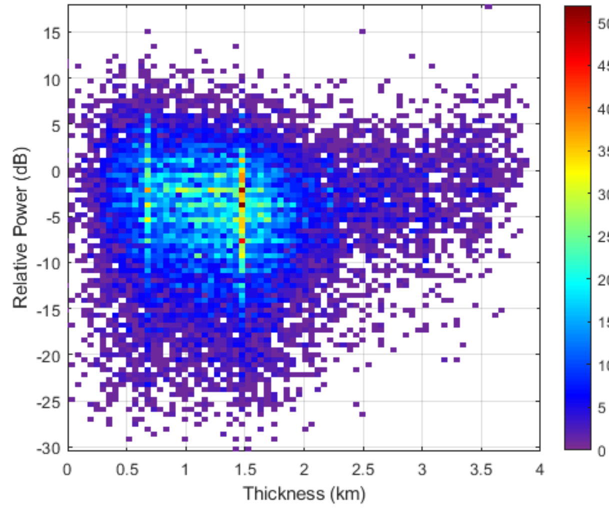

Figure 3. *Two-dimensional histogram of basal interface reflected power relative to that of the average SPLD surface, versus SPLD thickness. 4.0 MHz MARSIS data are shown here.*

Further analysis of this rich MARSIS dataset is ongoing, to better characterize the basal interfaces using all available frequency bands.

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