ANALYSIS OF THE RADAR PROPERTIES OF THE SOUTH POLAR LAYERED DEPOSITS ON MARS USING SHARAD DATA. J. L. Whitten[1] and B. A. Campbell[1], [1]Center for Earth and Planetary Studies, Smithsonian Institution, MRC 315, PO Box 37012, Washington, DC 20013 (whittenj@si.edu).

Introduction: The South Polar Layered Deposits (SPLD) are composed of layers of predominantly water ice with variable amounts of dust. These layers are interpreted to preserve a record of recent climate changes on Mars, their accumulation controlled by changes in orbital forcings (e.g., obliquity) [1]. The SPLD are ~3.5 km thick [2] and cover 1.4×10^6 km^2. These characteristics, combined with crater model ages [3, 4], suggest that the SPLD may preserve an older record of climate compared with the North Polar Layered Deposits. Thus, characterization of the SPLD layer structure will provide important information for better understanding the climate of Mars and its changes over the last <7–100 Ma.

Previous research on the internal structure and stratigraphy of the SPLD has predominantly used images. It was concluded that the SPLD have a gently domical shape and that at least some layering traverses the entire deposit [5–7]. Unconformities are visible in the images, indicating multiple periods of deposition and erosion. Approximately 2–3 different geologic units have been identified in each of these previous studies based on layer continuity and cadence, and the presence of unconformities.

In this study, we use SHARAD radar sounder data to investigate the radar properties of the SPLD and its subsurface reflectors to further characterize its internal structure.

Methodology: Radar sounder data from the SHARAD instrument on the Mars Reconnaissance Orbiter spacecraft [8] were used to map the radar characteristics of the SPLD. SHARAD has a chirp frequency center at 20 MHz and a bandwidth of 10 MHz. The along-track resolution of the data is 0.3–1.0 km and the vertical resolution is ~15 m in free space, or ~8 m in geologic materials.

SHARAD radar echoes are not able to completely penetrate the SPLD and data from this region of Mars can have a low signal-to-noise ratio due to scattering and attenuation of the signal. To combat this, a processing technique referred to as incoherent summing is applied to the SHARAD data to increase SNR [9–10]. Radargrams are converted from time-delay space to depth using a dielectric value (ε') of 3.15.

Results: Three distinct radar facies and one radar “signature” were identified. The three radar facies are: (1) shallow layers (SL) that are well-focused and densely spaced, (2) less densely spaced layers that range from focused to blurred (and will be referred to as either focused layers, FL, or blurred layers, BL), and (3) low reflectivity zones (LRZ) (Figs. 1 and 2). Of these facies, only the SL and LRZ have a clear stratigraphic position, being near the top of the SPLD. Where overlapping, the SL overlie the LRZ. The variably blurred layers are located throughout the vertical column of SPLD, transitioning between being focused to blurred with horizontal distance along a SHARAD track. The FL and BL layers are subdivided into regions of average brightness and above-average brightness (FL_N versus FL_B; Figs. 1 and 2).

Unconformities are observed within the focused layers, specifically in Promethei Lingula and on the far eastern end of Ultima Lingula regions of the SPLD. Two types of unconformities are present, those where radar reflectors intersect the surface of the SPLD and those that are confined to the subsurface where truncated reflectors are angularly overlain by reflectors that parallel the surface topography.

The distinct radar signature observed is referred to as fog. It is characterized by a diffuse radar echo spread over a large rage of time delay, and is mapped over ~2/3

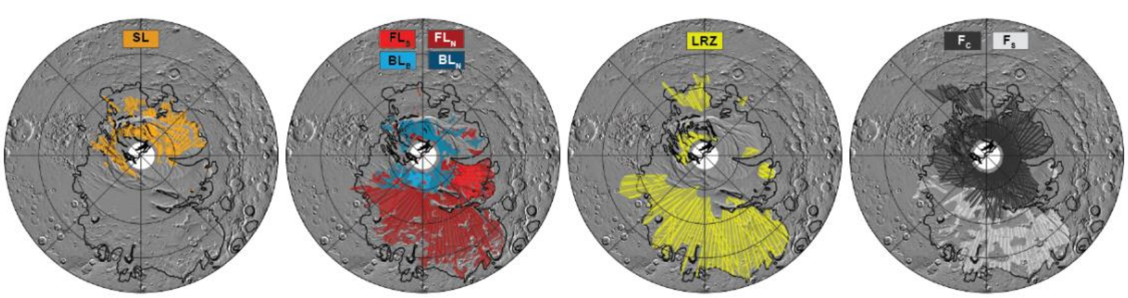

Figure 1. Distribution of the mapped radar facies, Shallow Layers (orange), Focused and Blurred Layers (FL and BL), Low reflectivity zones (LRZ), and radar behavior, fog (F_C and F_S), identified in SHARAD data for the SPLD (black outline). MOLA 128 ppd hillshade.

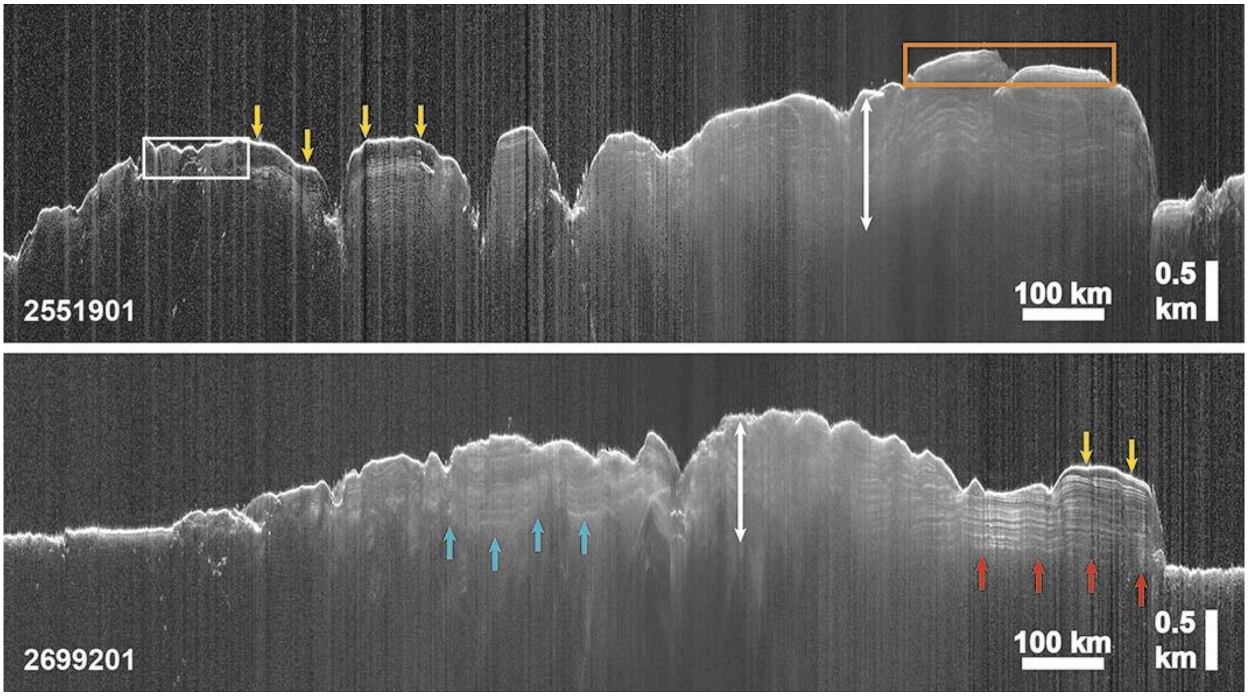

Figure 2. Examples of the radar facies and fog in SHARAD radargrams (tracks 2551901 and 2699201). The location of Shallow Layers are indicated by the orange boxes. The Focused Layers and Blurred Layers by red and blue arrows, respectively. Examples of two different low reflectivity zones are indicated by yellow arrows in the radargrams. The fog behavior is denoted by a white double-headed arrow for the full column fog (F_C) and by the white box for the near-surface fog (F_S).

of the SPLD area. There are two types of fog: one that overlaps much of the vertical column (i.e., long time delay) of the SPLD (F_C), and a second that is observed in only the uppermost ~500 m (F_S). The fog onset does not occur until the base of CO_2 ice deposits [e.g., 11], suggesting that the formative mechanism is overlain by the CO_2.

Discussion: Due to the obscuring effects of the fog only the uppermost km of radar reflectors in the SPLD are clearly visible. The increased SNR from the incoherent summing technique suggests that at least some of the FL and BL form a single layer-sequenced deposit, though the variable degree of vertical blurring individual reflectors makes it difficult to trace their continuity.

The cause of the fog signature is unclear. Only a few other deposits exhibit a similar radar behavior to the fog, including dune fields, the NPLD basal unit, and Medusae Fossae. However, these other behaviors do not exactly match the SPLD fog effect, "beneath" which focused reflectors can often be observed. This behavior can be caused by either volumetric scattering or a rough interface. Based on the geological history of the region, the fog might arise from a lag deposit on the surface of the SPLD. However, there is no evidence that the fog is correlated with surface roughness, as measured by MOLA [12], and any such micro-topography would need to be ubiquitous over large areas. No distinct surface textures have been associated with the fog. Another possibility is a structure or mechanism that mimics volume scattering or a frequency-dependent dispersion of the signal.

Conclusion: SHARAD data indicate that layers are likely continuous across the SPLD, to depths of at least ~1 km. There is only one major deviation from near-horizontality of the reflectors, but there is no evidence for major unconformities that separate distinct vertical sections within the cap. The fog behavior is widespread across the SPLD and causes attenuation and scattering of the radar echo. It greatly hampers mapping of radar reflectors in the SPLD below a certain depth, but future summing of additional collected tracks and/or signal processing approaches may mitigate this effect.

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