DETECTION OF A SUBSURFACE DOME IN THE SOUTH POLAR LAYERED DEPOSITS OF MARS.
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: A large area of the south polar region of Mars is covered with alternating layers of ice and dust, known as the South Polar Layered Deposits (SPLD) (Fig. 1). The vertical spatial frequency and thickness of these internal layers preserve information about the climate history of Mars over the past 10-100 Ma [1, 2]. The SPLD layer structure is hypothesized to be related to variations in orbital parameters, such as obliquity, eccentricity and precession [e.g., 3].

Previous analyses of SPLD layering exposed in troughs and at the edge of the deposit were conducted using visible images [4, 5]. [4] and [5] concluded that the internal layers have a gently dipping dome shape centered in Australe Mensa. Three major layer sequences, from top to bottom: the Bench-Forming Layer (BFL), Promethei Lingula Layer (PLL), and the Inferred Layer (IL) [5], were identified based on layer morphology and structure. The lowermost layer sequence (IL) has not been observed and is inferred based on the elevation variations of the PLL sequence.

Characterization of the internal structure of the martian polar layered deposits will provide information to constrain the climate history of the south polar region, as well as the SPLD mode of emplacement. For example, if a deeply buried CO_2 ice reservoir is detected, that would have implications for the past atmospheric pressure. The extent of each of the three layer sequences and associated unconformities provides information about the erosional history and/or depositional history of the SPLD. Evidence for flow or deformation of layers and their position within the stratigraphy of the SPLD would provide information about past polar temperatures.

Previous studies have relied on visible images to characterize the internal structure of the SPLD, which confined these analyses to only small windows into the SPLD subsurface. Here, we use radar sounder data to see into the subsurface and physically trace the extent and shape of reflecting interfaces across the SPLD.

Methodology: Radar sounder data (~160 tracks) from the SHARAD instrument on the Mars Reconnaissance Orbiter spacecraft were utilized to map the subsurface layers in the SPLD. SHARAD has a 10 MHz bandwidth centered at 20 MHz [6], meaning it has a vertical resolution of 15 m in free space; this resolution decreases in geologic materials. The along track resolution is 0.3–1.0 km. SHARAD data provides a unique opportunity to view the subsurface of the SPLD and trace layers continuously across the cap, in contrast to analyses using visible images.

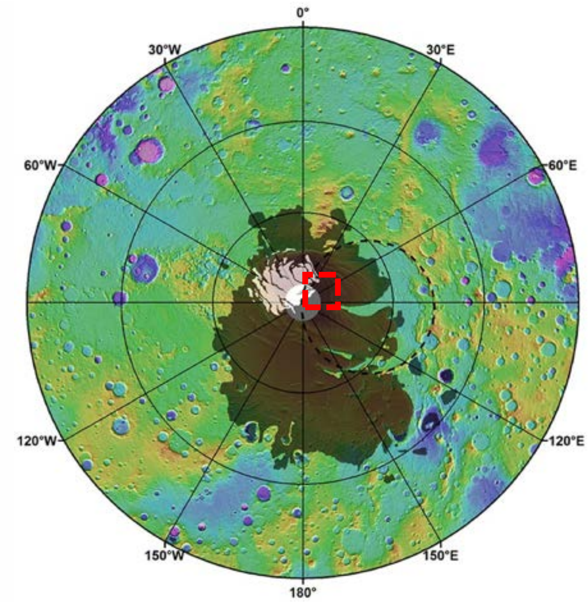

Figure 1. The location of the South Polar Layered Deposits (black polygons; SPLD). Red box shows location of the identified dome (Figure 2), just east of the residual cap (white polygons). Black circle outlines the rim of the Prometheus Basin. MOLA 128 ppd (~0.5 km/pixel) gridded topography <55°S over hillshade basemap.

Due to the dispersive behavior of the SPLD at SHARAD radar wavelengths, the radar signal does not penetrate to the base of the deposit except in isolated locates. A technique referred to as incoherent summing was developed to increase the signal-to-noise ratio [7] and, thus, increase the visibility of subsurface echoes in the thickest part of the SPLD. The technique involves incoherently summing all radar echoes overlapping within X km of a reference track; data processed with this technique is referred to as “summed”. The SHARAD data are also depth-corrected, assuming a real dielectric constant (ε”) of 3.15 [8, 9].

Results: Most of the observed subsurface radar echoes in the SPLD lay horizontally when depth-corrected for water ice. The radar echoes are most distinct near the edges of the deposit and in other relatively thin areas of the SPLD, such as Promethei Lingula. The base of the SPLD is not visible in summed data overlapping the thickest parts of the deposit. One region of echoes substantially deviates from horizontal layering, located just to the east of Australe Mensa (Fig. 1, 2), and is detected in both the unsummed and summed data. These SHARAD radar echoes form a dome-shaped feature approximately 210 km in diameter. Due to the data gap south of 87.5°S it is difficult to fully measure the morphology of this dome-shaped feature. There are no obvious unconformities or layers pinching out near the dome. Additionally, the thickness of individual radar dark and radar bright layers varies across the dome (Fig. 2). The thickest sections of the layers are at the dome crest, thinning down the sides of the dome.

Discussion: There are several possible explanations for this observed dome structure in the SHARAD coverage of the SPLD: (1) the presence of CO_2 ice layers, (2) deflection of the layers from basal topography or another pre-existing structure, and (3) an ice/snow depositional center. Only water ice is assumed for the depth-correction calculations. If a thick CO_2 ice layer is present, it would distort upwards any underlying interfaces in the water ice-corrected SHARAD radargrams. Calculations suggest that there is not enough material above the dome for CO_2 ice to account for the observed layer deviation from horizontal. There is no obvious deflection in basal topography that could form the dome [10]; the rim of the Prometheus Basin does not overlap with the dome location (Fig. 1). There has not been a detailed analysis of south polar climate models to assess SPLD emplacement. However, the presence of depositional centers can be inferred from distinct local layer sequences [11]. The variation in the extent of the three main SPLD layer sequences (BFL, PLL, IL) and the residual south polar cap hints that the area of accumulation has migrated over time. This, coupled with the inability of the first two hypotheses to explain the observations, indicates that the SPLD dome feature is likely a preserved ancient depositional center.

References: [1] Herkenhoff K.E. & Plaut J.J. (2000) *Icarus, 144,* 243–253. [2] Koutnik M. et al. (2002) *JGR, 107,* E11. [3] Thomas P. et al. (1992) Ch. 23 *in*: Mars. *LPS XXVII,* 1344–1345. [4] Byrne S. & Ivanov A.B. (2004) *JGR, 109,* E11001. [5] Milkovich S.M. & Plaut J.J. (2008) *JGR, 113*, E06007. [6] Seu R. et al. (2007) *JGR, 112*, E05S05. [7] Campbell B.A. et al. (2015) *LPS XXXXVI*, Abstract #2366. [8] Johari G.P. (1976) *J. Chem. Physics, 64*, 3998–4005. [9] Grima C. et al. (2009) *GRL, 36*, L03203. [10] Plaut J.J. et al. (2007) *Science, 316*, 92–95. [11] Putzig, N.E. et al. (2009) *Icarus, 204*, 443–457.

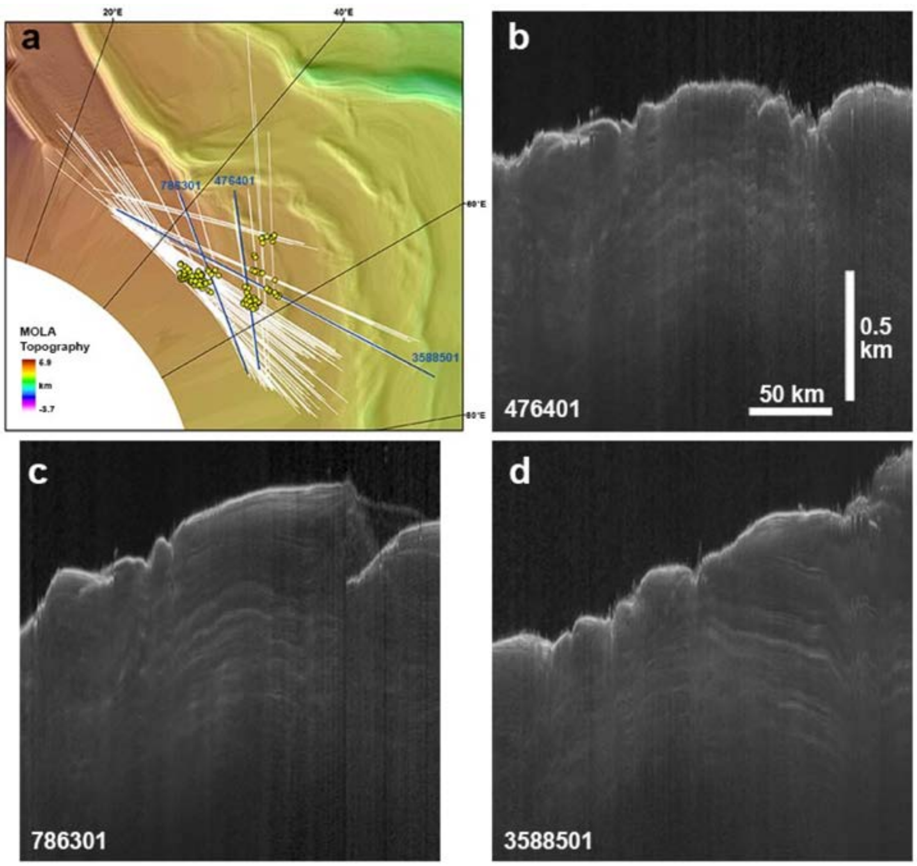

Figure 2. The subsurface dome identified in the SHARAD data. (a) Close view of the region, with the extent of the dome being indicated by subsections of SHARAD data tracks (white lines). Yellow dots denote the location of the crest of the feature in each track. Navy blue lines show locations of panels b-d. Close views of the dome identified within summed radargrams: (b) 476401 (c) 786301, and (d) 3588501. The scale in panel b also apply to panels c and d.