**PLACING CONSTRAINTS ON THE COMPOSITION AND EMPLACEMENT OF THE DORSA ARGENTEA FORMATION.** J. L. Whitten[1], B. A. Campbell[2], J. J. Plaut[3] [1]Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA 70118 (jwhitten1@tulane.edu), [2]Center for Earth and Planetary Studies, Smithsonian Institution, Washington DC, 20013, [3]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

**Introduction:** The Dorsa Argentea Formation (DAF) represents a large potentially ice-rich deposit, dated to the Early Hesperian period [1–3], that encircles the Amazonian-aged south polar layered deposits (SPLD). The DAF has been interpreted as the remnants of an Hesperian-aged ice cap that has largely melted away, but other formation mechanisms are still under consideration (e.g., volcanic activity, debris flows, aeolian deposition) [2, 4–7]. This interpretation means that the DAF represent the oldest record of climate in the south polar region of Mars and, if it occurred, may preserve evidence for the presence of multiple ice sheets in the south polar region throughout the geologic history of Mars.

The DAF is an areally extensive deposit, ~1.5 $\times 10^6$ $km^2$ (Fig. 1). Most of the DAF is contiguous, except for a deposit of material on the floor of the Prometheus Basin around 90°E. The DAF extends from the northernmost extent of the SPLD up to 55°S. There is a diverse suite of geologic landforms contained within the DAF, including pedestal craters, sinuous ridges, and pitted terrain. Previous researchers have subdivided the deposit into up to six morphologic subunits [2, 5].

If volatile-rich materials are detected in the DAF, that would provide support for a glacial origin. Here, we use a combination of radar sounder data, topography and imagery to characterize the composition of DAF materials. Because DAF represents one of the oldest and largest potential water ice reservoirs, determining its composition would provide critical information for understanding the early climate fluctuations and the hydrological cycle on Mars.

**Methods:** Radar sounder data from both the SHARAD instrument on NASA's Mars Reconnaissance Orbiter spacecraft [8] and the MARSIS instrument on ESA's Mars Express [9] are used to map subsurface radar reflectors in the south polar region of Mars. 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. MARSIS operates at four frequencies (1.8, 3.0, 4.0, and 5.0 MHz) and has a bandwidth of 1 MHz. The along-track resolution of the MARSIS dataset is 5–10 km and the cross-track resolution is on the order of 10–30 km.

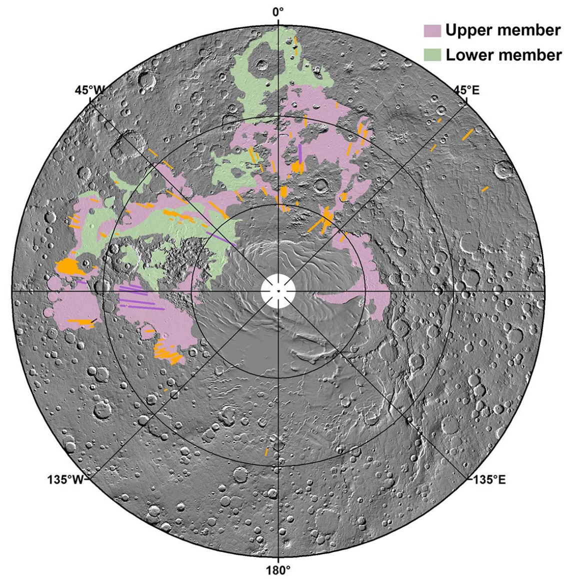


**Figure 1.** Location of SHARAD subsurface reflectors identified in the DAF (orange lines). Purple lines are SHARAD surface reflectors associated with confined near-subsurface scattering. Geologic map of the upper and lower members of the DAF [5, 11].

For this study, MARSIS data collected at 4.0 and 5.0 MHz and processed using the technique of [10] are used to identify and map the distribution of subsurface reflectors that correspond to the mapped extent of the DAF [5, 11]. Loss tangent values were calculated [e.g., 12, 13], assuming a homogeneous layer of material between the surface and subsurface radar reflectors, to estimate the composition of the materials.

In addition to the radar datasets, Context Camera (CTX) images and Mars Orbiter Laser Altimeter (MOLA) Precision Experiment Data Record (PEDR) data are employed to estimate the thickness of materials in the pitted regions of the DAF (Fig. 2) and assessing the morphology of the surface immediately above detected SHARAD and MARSIS reflectors. Thickness measurements will be used to assess plausible dielectric constant values for materials adjacent to DAF cavi deposits. CTX data will also be used to assess variations in morphology, based on the extent of the six DAF subunits identified [2], and differences in radar properties observed in the SHARAD and MARSIS datasets.

**Preliminary Results:** Several dozen MARSIS tracks were used to calculate loss tangent values for the

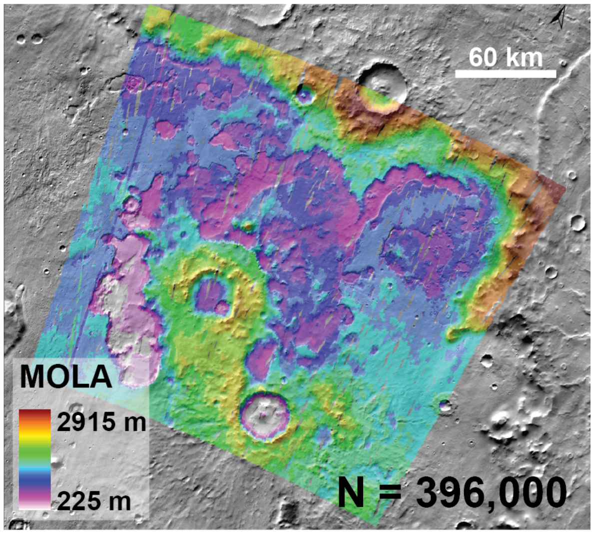


**Figure 2.** Variations in the thickness of the pitted terrain of Sisyphi Cavi that can be used to estimate the dielectric constant of proximal SHARAD tracks. MOLA PEDR data, 396,000 points.

DAF. The majority of the MARSIS data gave relatively high loss tangent values, >0.005, consistent with values derived for dry sediment [12] and basalt [13] using SHARAD data. Less than five tracks produced values consistent with some fraction of water ice (<0.005 [14]) (Fig. 3). Based on an assessment of confidence levels, the higher loss tangent calculations are more reliable than the lower values. This has to do with the increased variability in power and time-delay for the MARSIS dataset, compared with the SHARAD dataset.

Identified SHARAD reflectors in the DAF are much closer to the surface and represent a change in material properties in the near subsurface. Several identified subsurface SHARAD reflectors are near Cavi Angusti and Sisyphi Cavi. These SHARAD reflectors will be used to approximate the dielectric constant of the DAF in these regions, assuming a thickness derived from the MOLA PEDR measurements. Preliminary measurements of Sisyphi Cavi produce thickness estimates on the order of 100 m to 500 m. Most of the Sisyphi Cavi materials have a depth of ~200 m.

There is a loose correlation between the different behaviors observed in SHARAD data and at least two geologic subunits identified in the DAF (Fig. 1). Focused reflectors are identified in SHARAD data, as well as discrete regions of near-subsurface scattering. Generally, the regions of near-subsurface scattering are associated with the upper member of the DAF, while the more focused subsurface reflectors are associated with the lower member of the DAF. These results will also be compared with the six subunits that have been defined [2].

The current loss tangent results suggest that the DAF is composed predominantly of dry sediments or more consolidated materials, such as basalt. Based on the derived loss tangent results and other geologic landforms observed within the DAF (e.g, pedestal craters, cavi, dorsa, channels originating from the DAF boundary), the deposit was likely emplaced as a large ice sheet was receding or melting. Any volatiles associated with the original incarnation of the DAF have been removed from the current DAF materials; there is little evidence for preserved ancient massive ice in the DAF.

**References:** [1] Plaut J. J. et al. (1988) *Icarus, 75,* 357–377. [2] Tanaka K. L. & Kolb E. J. (2001) *Icarus, 154,* 3–21. [3] Kress A. M. & Head J. W. (2015) *PSS,* 109–110, 1–20. [4] Head J. W. & Pratt S. (2001) *JGR,* 106, 12275–12299. [5] Tanaka K. L. & Scott D. H. (1987) USGS I-Map 1802-C. [6] Kargel J. S. & Strom R. G. (1992) *Geology*, 20, 3–7. [7] Jöns H.-P.(1992) *LPSC* 23, Abstract 1314. [8] Seu R. et al. (2004) *PSS*, 52, 157–166. [9] Picardi G. et al. (2005) *Science, 310*, 1925–1928. [10] Campbell B. A. and Watters T. R. (2016) *JGR*, 121, 180–193. [11] Skinner J. A. et al. (2006) *LPSC* 37, abstract #2331. [12] Campbell B. A. et al. (2008) *JGR*, 113, E12010. [13] Carter L. M. et al. (2009) *GRL*, 36, L23204. [14] Plaut J.J. et al. (2007) *Science*, *316*, 92–95.

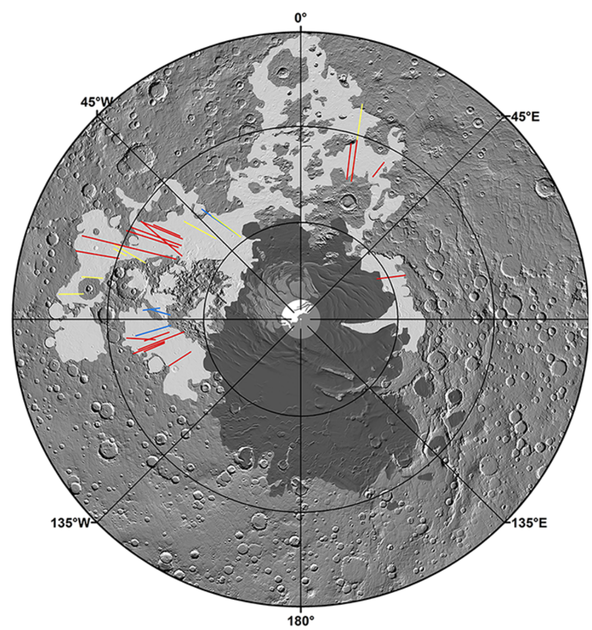


**Figure 3.** Loss tangent results derived from the MARSIS dataset. Red lines correspond to materials with loss tangent values from 0.010 to 0.037 that are consistent with more consolidated materials. Yellow lines represent loss tangent values between 0.005 and 0.009 (dry sediment) and blue lines represent values <0.005, consistent with water ice.