INITIAL SHARAD OBSERVATIONS OF INTERNAL LAYERS IN THE UPPERMOST NORTH POLE LAYERED DEPOSITS OF MARS. J. W. Holt1 (jack@ig.utexas.edu), R. J. Phillips2, R. Seu3, J. J. Plaut4, A. Safaeinili4, D. Biccari5, B. A. Campbell5, L. M. Carter5, C. J. Leuschen6, R. Orosei7, G. Picardi3, S. E. Smrekar4, N. E. Putzig8, A. F. Egan9, F. Bernardini2 and the SHARAD Team; 1University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758; 2McDonnell Center for the Space Sciences and Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130; 3INFOCOM Department, University of Rome “La Sapienza,” 00184 Rome, Italy; 4Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109; 5Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560; 6Center for Remote Sensing of Ice Sheets, U. Kansas, Lawrence, KS 66045; 7Istituto di Astrofisica Spaziale e Fisica Cosmica, Istituto Nazionale di Astrofisica, 00133 Rome, Italy.

Introduction: The SHAllow RADar (SHARAD) instrument on Mars Reconnaissance Orbiter expands our ability to study internal features of the Polar Layered Deposits (PLDs) relative to previous optical and spectral imagery as well as successful soundings accomplished by MARSIS on Mars Express [1, 2].

SHARAD is an orbital, chirped radar on MRO, operating at a 20 MHz center frequency (15 meters free-space wavelength) with 10 MHz bandwidth and 85 µs pulse duration [3, 4]. Pulse compression yields a theoretical vertical resolution of ~ 8 m in water ice. Horizontal resolution is 0.3 – 1 km along-track and 3 – 6 km across track. Penetration in the martian regolith is expected to be less than a few hundred meters for SHARAD, but much greater within the PLDs based on results from MARSIS [1, 5].

First results from MARSIS over the NPLD showed a strong basal reflector at ~ 2 km depth, implying low radar attenuation at 1 - 5 MHz [1]. Distinct internal layers were not resolved, likely due to the limited vertical resolution of MARSIS (ten times that of SHARAD).

Initial SHARAD observations show two fairly distinct units in the NPLD, an upper unit ~ 600 m thick consisting of many bright reflectors, and a lower unit that is over 1 km thick with fewer and weaker reflectors [2, 6, 7].

This study presents initial results of SHARAD over the Northern PLD (NPLD) with an emphasis on layer character in the upper ~ 500 meters in the NPLD lobe that extends along the southern edge of Chasma Boreale, informally termed Titania Lobe [8]. Characteristics of these layers including major features, thicknesses, and lateral continuity are examined. For purposes of this abstract, this layer package is denoted as the Upper Layer Sequence (ULS).

Methods: Titania lobe was selected for this preliminary analysis due to its generally smooth, low-slope surface which reduces ambiguities that can result from sloping interfaces. Surface topography away from the edges is minimal, helping to reduce potential surface clutter. The longitudinal crest of Titania Lobe is an ice divide [9] which, based on radar sounding data of ice sheets on Earth, should provide the most stable environment for preservation of internal layering [10].

Segments of three data acquisition passes (Fig. 1) were analyzed (Fig. 2). Two of these follow paths that are nearly parallel (orbits 2648 and 2859), with average separation of ~ 10 km. Another pass (orbit 2943) is included that intersects the first pair near the northern edge of the lobe and diverges to a point ~ 100 km from the point of intersection.

The data shown here were processed using an unfocused synthetic aperture method with 64 pulses summed. Steeply sloping interfaces near the edges of the NPLD are not generally resolved well. Comparisons focus on the interior of Titania Lobe where these effects are not an issue.

Results: Overall observations are: (1) The ULS extends to approximately 600 meters depth, and this depth is quite consistent over the region studied. (2) Generally, the layers in the ULS conform to surface topography.

Stratigraphy: (1) Based on the time delay between

Figure 1. Location of data used in this study. Orbit segments used are indicated in black.
Figure 2. SHARAD data from the upper portion of profiles across Titania Lobe. Vertical scale is 7.5 µs time delay, horizontal distance is ~ 100 km. All profiles are shown with northern end at left. Ground tracks of (a) and (b) are approximately 10 km apart. Left edge of (a) is near intersection with left edge of (b) and they diverge from there, until separated by ~ 100 km. Note that the horizontal discontinuity near the right side of (a) and the relative tilt between profiles are artifacts of acquisition and processing.
peaks in brightness, and the assumption of a typical radar velocity in H$_2$O ice (0.168 m/ns), layers range in thickness from ~ 9 m to ~ 25 m in the ULS. Many are near the limit of resolution of SHARAD, and interference from closely-spaced returns is seen in some cases, making the identification of thin layers difficult. (2) Overall layer sequences, based on thickness and brightness variations, are generally consistent over the distances observed here, with some bright returns being traceable across the full length of these segments (~100 km). However, some of the weaker echoes from thin layers cannot be traced farther than a few tens of kilometers before disappearing or merging with another layer.

**Structure:** (1) Features observed in the radar data indicate structures within the ice. (see sloping feature in center of Figs. 2b and 2c, in particular). Layer disruption appears to extend to the surface, or very close to it, with more extensive disruption at greater depths. (3) From the apparent correspondence of this feature in these orbits, it appears that such structures may extend over distances of many tens of kilometers.

**Conclusions:** (1) SHARAD detects layering in the upper 600 m of the NPLD that is laterally extensive, generally continuous and consistent in overall character across distances of 100 km or more. (2) The thickness of these radar layers approach the theoretical vertical resolution limit of SHARAD, ranging from ~ 9 – 25 m, assuming a composition of water ice. (3) Cross-cutting structures in the ice disrupt layering and appear to reach the near-surface, indicating that they are recently active features.