MAPPING THE INTERNAL STRUCTURE OF THE NORTH POLAR PLATEAU USING MARSIS AND SHARAD.

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Introduction: Using laterally extensive reflectors in the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) and Shallow Subsurface Radar (SHARAD) data, we map out the large-scale internal structure of the North Polar Plateau (NPP) on Mars. We use this 3D mapping to identify various interfaces within and at the base of the plateau, and to estimate volumes between these interfaces.

Background: Images from the boundaries of the NPP reveal clues to its internal layering. The North Polar Layered Deposits (NPLD) consist of two distinct units, the brighter upper layers (Apl) and the lower Basal Unit (BU) [1, 2]. The Apl is composed of thin layers of nearly pure water ice, while the BU is darker and more resistant to erosion, suggesting the inclusion of a greater amount of contaminants such as dust and/or sand [1].

The BU extends beneath much of the Apl, but is distinctly absent in MARSIS data under the large lobe south of Chasma Boreale [3, 4], as predicted from images of the walls of Chasma Boreale [2]. MARSIS also reveals that the reflector at the bottom of the BU is apparently continuous with the strong subsurface reflector in the distal Olympia Undae region [4, 5], which is consistant with imagery [1].

A previous estimate of 2.7 x 10^5 km^3 for the volume of the BU is based on mapping its contacts with the Apl above and the Vastitas Borealis Formation below, using Mars Orbiter Camera (MOC) images [1]. The vertical extent of the BU is difficult to determine from imagery, and will be improved upon with the radar imaging methods in this study.

MARSIS and SHARAD see many laterally extensive reflectors in the NPLD. The common assumption when interpreting these reflections is that they are due to changes in the amount of contaminants. For example, increased dust concentration may be due to volcanic fallout, global dust storms, and/or enhanced sublimation. This intuitive explanation for internal reflections is complementary to the observation of many laterally extensive layers (albedo variations) in images of the NPLD.

In contrast, internal reflections in terrestrial ice sheets are correlated with variations in density, acidity, and crystal-orientation fabric, with acidity having the dominant effect at frequencies below ~60 MHz [6]. The Mars polar materials are being investigated at frequencies of 20 MHz (SHARAD) and 1.3-5.5 MHz (MARSIS), with reflectors detected to depths of more than 3 km [3, 7]. The frequency coverage of Martian radar investigations indicates that acidity may be the primary cause of deep internal reflectors in the polar deposits. On Mars acidity may be linked to volcanism, as it is on Earth [8].

By tracing internal reflectors in MARSIS data to nearby outcrops of the South Polar Layered Deposits (SPLD) with high-resolution image coverage, the strong returns are found to correspond with erosion-resistant packages of several thin layers [9]. This result suggests that the thin layers produce a strong radar return through positive interference, but it does not resolve whether or not acidity causes the return from each individual layer.

Methods: We use processed radar data from MARSIS on the Mars Express orbiter and SHARAD on the Mars Reconnaissance Orbiter to map out the large-scale internal structure of the NPP. Radargrams are corrected for the effects of the ionosphere and surface clutter, and are tied to Mars Orbiter Laser Altimeter (MOLA) elevations at the surface reflector. The conversion of time delay to depth is performed using the refractive index of pure ice with a real dialectic constant of 3.

We trace continuous reflectors in each radargram and combine the mapped horizons (particularly for the top and bottom of the Basal Unit) to delineate the internal surfaces. Together these surfaces define the 3D structure of the NPP. Similarly to the interpretation of MARSIS data at the south pole of Mars [7], we determine the surface elevation map for laterally extensive internal reflectors, as well as volumes of the distinct components of the NPLD.

Preliminary Results: The large-scale surfaces that are most readily apparent are the top and bottom of the Basal Unit, which is the lower component of much of the NPLD and extends from beneath the upper Apl layer into Olympia Undae (approximately centered on 180° E). An example of the continuity of the Basal Unit and the subsurface of Olympia Undae is provided in Figure 1a. The 11 Mars Express ground tracks used to initiate this study are shown in Figure 1b. With the inclusion of the ~150 MARSIS radargrams that cross the north pole, interpolation of interior surfaces will be possible.

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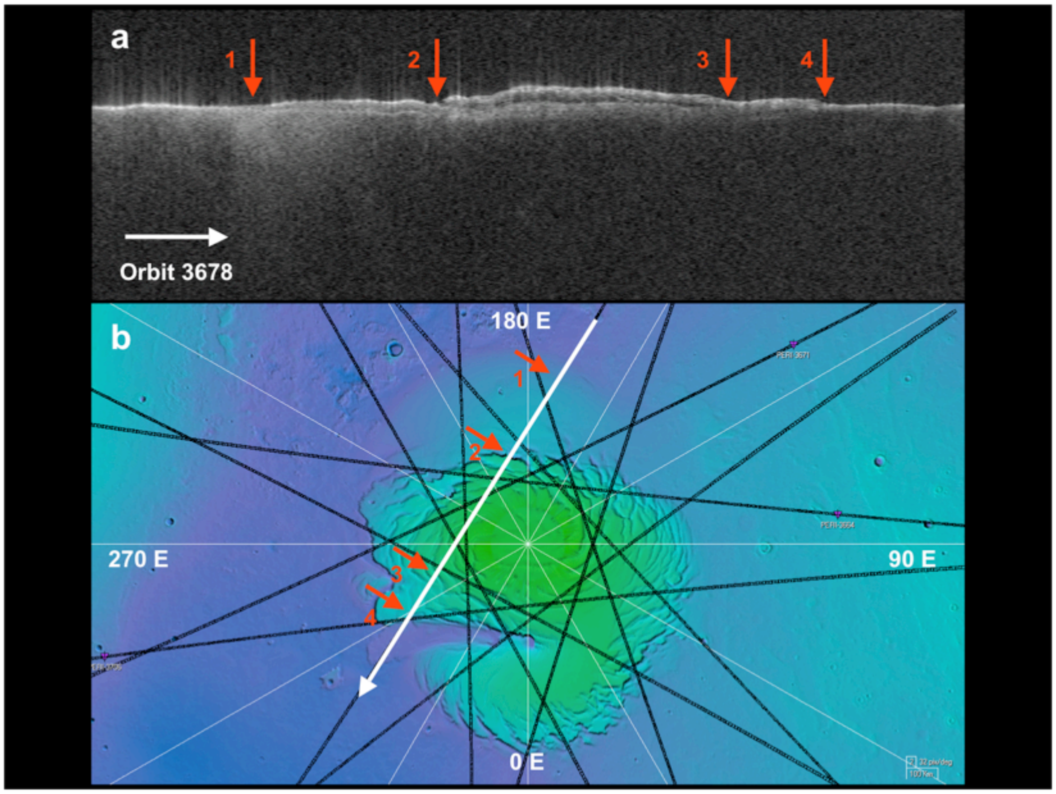

Figure 1: (a) MARSIS orbit 3678 displays distinct, continuous reflectors at the top and bottom of the Basal Unit (BU). The upper unit of the North Polar Layered Deposits (Apl) extends to the right of arrow #2, whereas the BU is continuous from the Olympia Undae region (between arrows 1 and 2) to below the Apl (right of arrow #2). Between arrows 3 and 4, the diffuse quality of the subsurface reflection suggests that the BU may be at the surface again. (b) Plotted on top of the MOLA surface topography in the north polar region, black lines depict the 11 Mars Express ground tracks used to initiate this internal reflection mapping project, and the white arrow shows the location of the MARSIS radargram above. Red arrows correspond to those in (a).