Subsurface Structure of Planum Boreum on Mars from Shallow Radar (SHARAD) Soundings

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ORIENTATION

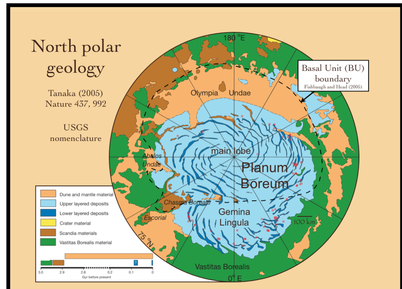
We present maps (rightmost panel) of the subsurface structure beneath Planum Boreum, obtained with results from the Mars Reconnaissance Orbiter (MRO) Shallow Radar (SHARAD) instrument. SHARAD has acquired sounding observations over the north polar region during more than 1300 orbits since the MRO primary science mission began in Nov. 2006. North polar radargrams (2-D profiles along the spacecraft ground track) typically show a series of returns from range delay times of 70 to 100 µs. The coverage map at right includes ground tracks labeled with observation number and color-coded to the borders of the radargram displays included below.

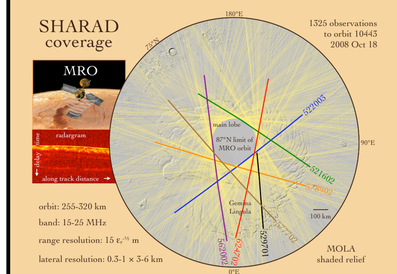
Apart from off-nadir surface clutter, the radar returns likely correspond to dielectric contrasts in the subsurface to depths of 2-3 km. At right, two delay-time radargrams from SHARAD observation 529701 show the correspondence of radar-detected layers to geologic units (Upper and Lower Layered Deposits and the Basal Unit) and the radar units assigned for our mapping work. The depth radargram provides a proper geometric representation of the radar returns, assuming water-ice properties in the subsurface.

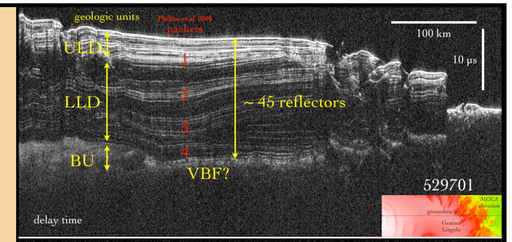
RESULTS

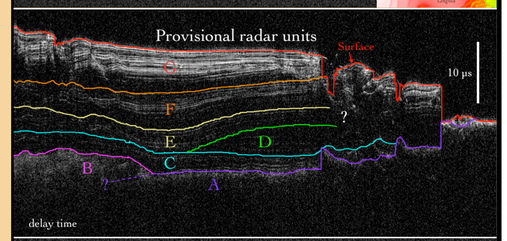
Using interactive interpretation software, we mapped packets of radar layers (Units C-G) within the North Polar Layered Deposits (NPLD) in three dimensions, from the surface down to either a relatively coherent basal reflection (Unit A) or a diffusely reflective zone (Unit B). Unit A is presumably an extension of the Early Amazonian Vastitas Borealis Interior Unit (Tanaka et al. 2008, Icarus 196, 318) under the NPLD. Unit B likely corresponds to a Basal Unit identified along the periphery using surface imagery (Byrne and Murray 2002, JGR 107 E6, 5044; Fishbaugh and Head 2005, Icarus 174, 444) and later mapped as the Rupes Tenuis and Planum Boreum cavi units (Tanaka et al. 2008).

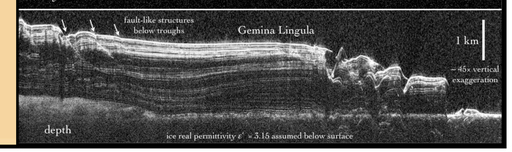
Within the NPLD, four radar units (C, E, F, and G) consist of alternating packets of strongly reflective layers and quiescent zones, and they extend into both lobes of the deposits. A fifth unit D) is isolated to eastern Gemina Lingula, pinching out below the topographic saddle that joins the two lobes of Planum Boreum.











DISCUSSION

While Unit B extends over most of the main lobe and Olympia Planum in keeping with the Basal Unit as mapped by Fishbaugh and Head (2005), portions also extend beyond Chasma Boreale and partly into the Gemina Lingula lobe. Additionally, there is a large region where Unit B is absent beneath the main lobe. Thus, we suggest a revised boundary for the Basal Unit beneath the NPLD (see left column of maps at right), which complicates scenarios suggesting that this boundary controlled the emplacement of Chasma Boreale.

The layering associated with the internal NPLD units is thought to be the result of variations in dust content within water-ice deposits, and the relatively quiescent zones may represent nearly pure ice. It has been suggested that the dust content variations—and thus the sequence of layers—are controlled by orbit- and obliquity-driven climate cycles (see Phillips et al. 2008, Science 320, 1182, and Levrard et al. 2007, JGR 112, E06012), but any detailed correspondence that would narrowly constrain the age of the deposits remains speculative.

With the exception of areas immediately below crosscutting troughs, the thickness of the NPLD is remarkably uniform across both lobes, tapering toward the edges, and most of the topographic difference between the two lobes is explained by the Basal Unit, which is found predominantly under the main lobe (see depth radargrams and right column of maps at right). While there are indications of a few angular unconformities (e.g., within right side of Unit G in observation 529701 at left), the layering within and between radar units is typically smoothly varying and quasi-parallel, in contrast to the more heterogeneous layering seen in the South Polar Layered Deposits (e.g., Seu et al. 2007, Science 317, 1715). Taken together, these characteristics suggest relatively uniform rates of deposition and very low rates of erosion across Planum Boreum throughout the history of the NPLD, regardless of its age.

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