CHASMA BOREALE, MARS: A PRODUCT OF NON-UNIFORM POLAR ACCUMULATION INFLUENCED BY BASAL TOPOGRAPHY. J.W. Holt[1], S. Byrne[2], K. Fishbaugh[3] S. Christian[4], N.E. Putzig[4], R.J. Phillips[4], K. Tanaka[5]; [1]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758 (jack@ig.utexas.edu); [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, [3]Smithsonian Institution, Washington DC, [4]Bryn Mawr College, Bryn Mawr, PA, [4]Southwest Research Institute, Boulder, CO., [5] U.S. Geological Survey, Flagstaff, AZ.

Introduction: The north polar layered deposits (NPLD) of Mars exhibit features that deviate significantly from what one would expect from the uniform deposition of ice (i.e., Chasma Boreale and the spiral troughs; Fig. 1). These features have mostly been attributed to focused erosion of a pre-existing stack of NPLD. Orbital radar sounding provides a new view into the interior of the NPLD enabling large-scale stratigraphic and structural studies. Using orbital radar sounding data we have produced maps showing how Planum Boreum evolved through alternating periods of deposition and erosion, leading to patterns of non-uniform accumulation that have determined today's landscape including the largest single anomaly, Chasma Boreale.

Methods: The Shallow Radar (SHARAD) instrument on Mars Reconnaissance Orbiter (MRO) is a chirped radar operating at a 20 MHz center frequency (15 meters free-space wavelength) [1]. Its 10 MHz bandwidth yields a theoretical vertical resolution of ~ 9 m in water ice. Horizontal resolution is 0.3 – 1 km along-track and 3 – 6 km across track. All of the NPLD and some parts of the underlying Basal Unit (BU) [2] are penetrated with SHARAD [3].

Data from SHARAD passes were processed with a focused synthetic aperture radar (SAR) technique in order to reduce along-track surface clutter and resolve reflectors with relatively steep slopes. Radar reflectors were traced using seismic analysis interpretation tools on hundreds of intersecting ground tracks. This allows the quantitative extraction of radar reflector positions in time and cross-correlation between lines.

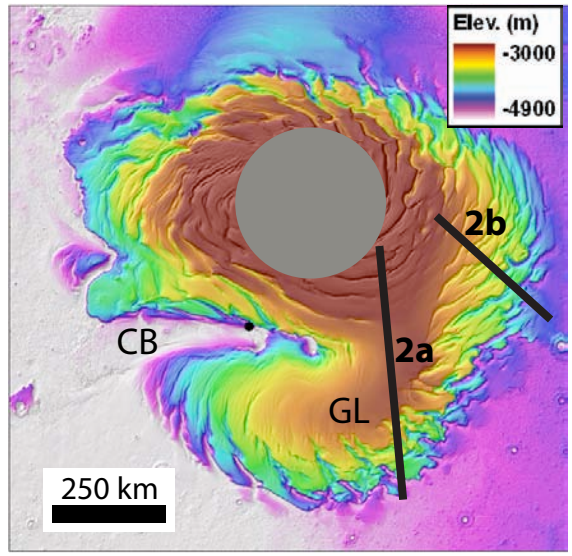

Figure 1. Shaded-relief Planum Boreum surface derived from MOLA data. GL = Gemina Lingula; CB = Chasma Boreale. SHARAD profiles shown in Fig. 2 indicated with solid lines.

Radar Stratigraphy: Many radar reflectors exist and most extend across the entire NPLD [3]. Due to the overall uniformity of layering patterns within the NPLD we can deduce that the main lobe and Gemina Lingula (GL) share the same depositional history (i.e., they span roughly the same interval of time and both have been subject to pan-polar deposition and ablation processes).

Stratigraphic mapping requires a basis for discerning distinct units, and vertical changes in radar charac-

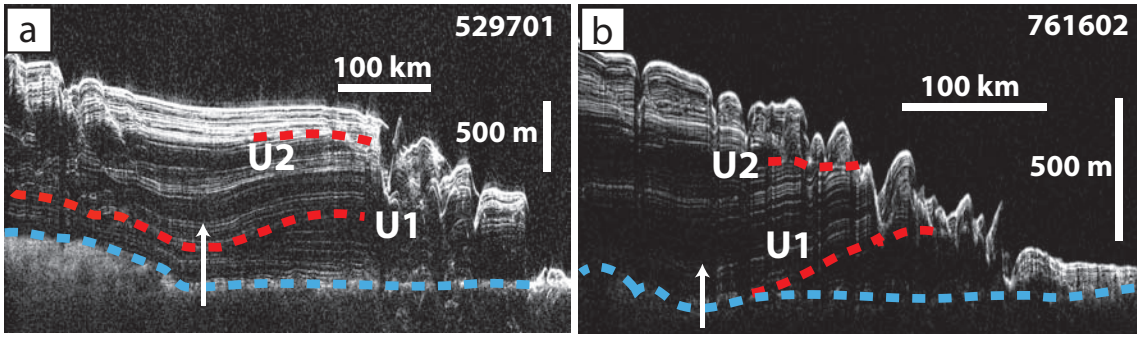

Figure 2. Representative SHARAD data from the NPLD showing the major stratigraphic unconformities. (a) observation 5297, and (b) observation 761602. See Fig. 1 for locations Base of NPLD indicated with dashed blue line. Major stratigraphic unconformities indicated with dashed red lines. Note uniformity of layering beneath the U1 unconformity. Vertical arrows point to infilling (thicker layers) of the now-buried chasma (COS; Fig. 3b) that was created during the U1 hiatus.

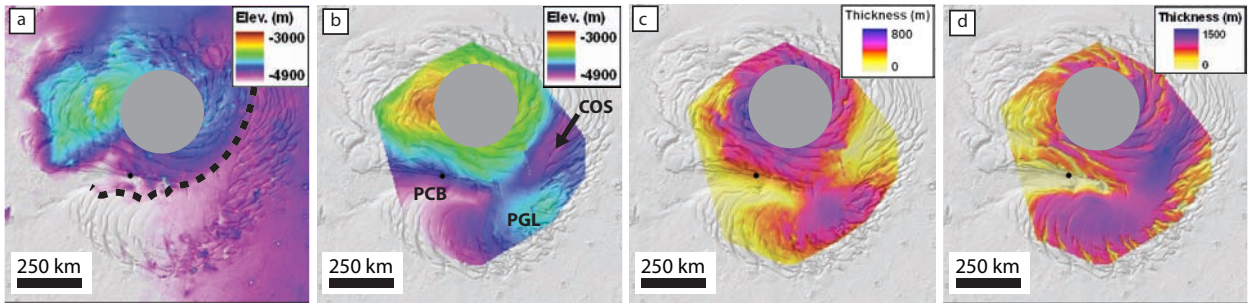

Figure 3. Paleo-surfaces and net accumulation maps. For all, the present-day surface is shown as semi-transparent, shaded-relief, greyscale overlay. (a) Base of NPLD, merged with surrounding MOLA elevations to show context and continuity. Buried boundary of BU shown as dashed line, as determined from our mapping. Merged with surrounding MOLA elevations to show continuity and context. (b) Surface elevation of unconformity U1 (Fig. 2) and its stratigraphic equivalent elsewhere. PGL = paleo Gemina Lingula; PCB = paleo Chasma Boreale; COS = Chasma Orientale Seputus (informal name). (c) Net accumulation thickness prior to the U1 surface. (d) Net accumulation thickness between U1 and present-day surface. Note change in value of color scale between (c) and (d).

ter can provide the means for this. Four major packets of bright radar reflectors separated by reflector-poor "dark" zones have been observed and mapped, and tentatively linked to orbital climate-forcing parameters [3, 4]. Alternatively, the presence of stratigraphic unconformities can be used to identify significant changes in accumulation (e.g., depositional hiatuses accompanied by erosion). This is demonstrated in Figure 2 where two major angular unconformities are identified (U1 and U2, Fig. 2). Each represents a hiatus in deposition followed by erosion.

Using the method described above, we first mapped the base of the NPLD using hundreds of SHARAD orbits, as in [4]. We then mapped the radar reflectors that immediately overly U1 across Planum Boreum, including where they are conformable to the underlying layers within the main lobe. Converting time delays to absolute elevation using the surface echo as a reference and a composition of water ice [3], we constructed maps of the base and the paleo-surface that existed at the end of the hiatus represented by the U1 unconformity (Fig. 2). These are shown in Fig. 3b. Mapping of the U2 paleosurface is underway. By differencing the U1 surface and the basal topography, we can quantify the net accumulation until that time. By differencing the present surface and the U1 surface, we can quantify the net accumulation since. These are shown in Figs. 3c and 3d, respectively.

Discussion: The maps show that in spite of initial deposition being widespread and uniform (indicated by near-uniform, subhorizontal radar layering below U1; Fig. 2a), the net accumulation pattern that includes erosion during the U1 hiatus was not uniform. An elongate, nearly isolated lobe of PLD was formed at this time, adjacent to the polar high created by the BU and early NPLD deposition. This lobe underlies the current GL but extended eastward to the present NPLD margin at approx. 45°E longitude. We therefore refer to it as a "proto GL" (PGL; Fig. 3b). This landscape also included a "proto CB" (PCB; Fig. 3b) and an eastern valley that is no longer evident on the Planum Boreum surface. We propose the informal name "Chasma Orientale Seputus" meaning buried, eastern chasm (COS; Fig. 3b). We hypothesize that high topography and steep slopes resulting from the BU surface produced katabatic winds that eroded the earliest NPLD deposits to form PGL, PCB, and COS.

During later deposition (Fig. 3d), COS was completely filled in while PCB was not. This is the strongest evidence for large-scale, non-uniform deposition within the NPLD. We propose that this was due to stronger total relief adjacent to PCB relative to COS, with the resulting influence of katabatic winds that reduced or prevented accumulation there. Coriolis deflection of polar winds may have also played a role.

The presence of PGL also clearly impacted today's topography, as layers above U1 drape the PGL surface (Fig. 2) and largely maintain its shape. In GL where the CB margin is best preserved, radar layers in this stage of accumulation drape continuously to the floor of CB without interruption [5].

Conclusions: We have shown through mapping of radar reflectors within and beneath the NPLD that although a period of mostly uniform deposition characterized the earliest phase of NPLD growth, non-uniform accumulation resulted from subsequent periods of erosion and non-uniform deposition. This led to the formation of two major valleys adjacent to the basal high; one was filled in while the other persisted and became known as Chasma Boreale.

Acknowledgements: This work was supported by an MRO-PS award and NASA grant NAG5-12693 to JWH. We thank P. Choudhary for assistance with data analysis.

References: [1] Seu, R. et al. (2007) *JGR*, 112. [2] Byrne and Murray 2002, *JGR* 107 E6, 5044. [3] Phillips et al. (2008) *Science*, 320, 1182-1185. [4] Putzig N. E. et al. (2009) Icarus, 204, 443. [5] Holt and Safaeinili, LPSC 40 (2009), #1721.