INVESTIGATING SUBSURFACE GEOMORPHOLOGY OF THE BASAL UNIT OF PLANUM BOREUM, MARS WITH SHARAD TO CONSTRAIN EARLY EROSIONAL PROCESSES T. C. Brothers[1], J. W. Holt[1], S. W. Christian[2], P. Choudhary[1], [1]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758 tcbrothers@mail.utexas.edu; jack@ig.utexas.edu; [2]Bryn Mawr College, Bryn Mawr, Pennsylvania 19010.

Introduction: The Basal Unit (BU) on Mars is a layered deposit of sand, dust and ice beneath the North Polar Layered Deposits (NPLD). The BU is characterized by thicker layers and a higher sand content than the overlying NPLD. This property gives it a darker appearance in optical imagery caused by a lower albedo [1] and in radar imagery the basal unit appears as a diffuse reflective zone [2].

Early information regarding the BU came from Mars Global Surveyor (MGS) and the Mars Orbiter Camera (MOC). MOC was capable of 1.5 meter per pixel resolution, well beyond Viking resolution [1]. Early researchers using MOC imagery noted that much of Planum Boreum (PB) was layered terrain and that beneath the lighter-colored layers of ice was a set of lower albedo layers [1].

A later study using MOC imagery further investigated BU composition [3]. The work stated that the BU is a platy unit, rich in either sand or sand-sized dust aggregates. To test this hypothesis they noted the BU's relationship to surrounding dune formations. The conclusion was drawn that saltating sand sized dust aggregates were not likely to remain intact long enough to migrate as dune fields into the circumpolar erg due to the saltation distances required [3]. As the BU seemed a likely source for the dune material, a sand component could not be ignored.

Subsequent work indicated that the BU should have a large unconformity separating it from overlying layers [4]. The BU was eroded providing material for the north polar dunes, erosion dominated by aeolian processes [3,4]. The extent of the BU was hypothesized to go well into Olympia Planum and to extend partially into Gemina Lingula.

A more detailed analysis of PB stratigraphy was undertaken by [5] who subdivided the BU into separate Rupes Tenuis and PB cavi units, with the cavi unit being significantly younger as evidenced by localized, gradational contacts with the lowermost NPLD. They also re-examined the areal extent of the BU and supported previous determinations of an Early Amazonian age and the presence of unconformities [4,5].

Orbital radar sounding has provided a new tool to study the interior of PB [2, 6-8]. Recent work has documented the extent of, and topography on, the BU using radar sounding and illuminated differing depositional centroids for the NPLD and BU [8].

Using the same technique, our objective is to illuminate the potentially complex erosive history of the BU and its role in shaping the present-day surface. As a distinction between PB cavi and Rupes Tenuis units has not yet been identified in radar sounding data, the term BU will be used in this paper.

Methods: We have employed data from the SHAllow RADar (SHARAD) aboard Mars Reconnaissance Orbiter (MRO) to investigate sub-NPLD topography. SHARAD is a sounding radar centered at 20-Mhz frequency with a 10-Mhz bandwidth [6]. The SHARAD system reliably penetrates all but the BU within PB [2].

Mapping of the BU was done using commercially available seismic data analysis software. Radar data are collected in time delay and must be depth corrected to ascertain reflector elevations and layer thicknesses. A dielectric constant of 3.15 was used for all depth corrections [9]. BU surface positions were georeferenced and gridded using ESRI's ArcGIS software. 294 SHARAD lines and 381,109 data points were used to create the BU map. Interpolation between gridded points employed the nearest-neighbor algorithm to create a continuous surface map of the BU and the adjacent surfaces beneath PB where the BU is not present (Fig. 1).

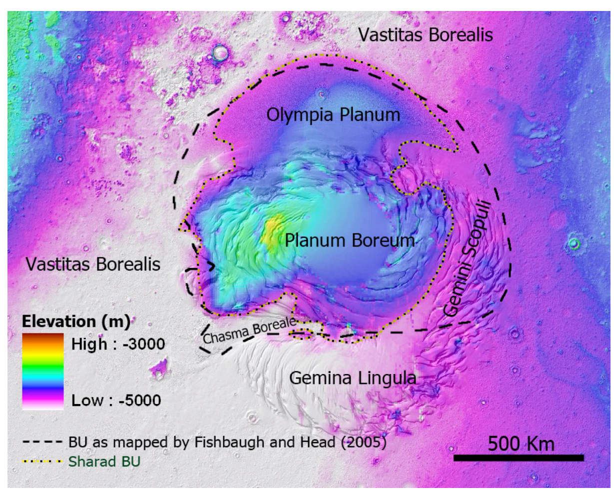

Figure 1: Map of the NPLD base elevation overlain on MOLA hillshade topography. Top of BU coincides with NPLD base where present. Semi-transparent shading is derived from the present-day surface elevation. The BU outline of [5] is shown along with the boundary defined using SHARAD data.

Observations: Radar mapping of the BU is enhanced by the contrasting dielectric properties of the relatively dust free NPLD and the sand and dust rich BU ice. The differing dielectric constants provide a strong, but often diffuse reflection from the top of the BU that can be traced across much of PB. The BU's topographic expression is far more variable than was indicated by optical imagery mapping alone. Zones of distinct relief, presumably due to erosion, were mapped east of Chasma Boreale (CB) and along the margin from 240° E to 300° E longitude. Nearly 1 km of relief is present spanning no more than a few tens of kilometers distance (Fig. 1).

In contrast to the high relief region, the zone 120° E to 240° E forms a nearly continuous arcuate surface of minimal relief. Here the BU extends beneath Olympia Planum. In contrast with earlier work [4], the BU does not extend beneath all of Gemini Scopuli on the eastern margin and ends near 80° N latitude (Fig. 1 and [8]).

Mapping of the BU has revealed many similarities between the BU's Early Amazonian surface and the modern NPLD surface. This is most clearly recognized on the western margin, adjacent to CB, and underneath Olympia Planum. The irregularity of the modern NPLD in these locations can be directly attributed to topography on the BU. Therefore, it becomes necessary to understand the morphology of the BU in order to understand modern NPLD morphology.

Conclusions: Mapping of the BU has unveiled many regions of complex topographic expression. The BU is not a simple mounded deposit on the North Pole, but rather an irregular surface with highly variable relief. Through these irregularities we may gain insight into pre-NPLD history and subsequent NPLD evolution.

The high relief area spanning 240° E to 300° E longitude in the BU is anomalous and indicates a different process affecting this region at a time either coeval with or shortly after BU deposition. Conditions in this region must have resulted in significant erosion of the BU to create the high relief, as this would be difficult to ascribe to depositional patterns alone. Inside CB a large scarp cuts into the BU leading towards the pole. It is possible that surface landforms interpreted as relating to the modern CB may in fact be the result of older erosion [5] and this BU relief may be related to such events.

The BU clearly dictates topographic expression in many parts of the NPLD (Fig. 1). It also appears that the BU was once a much more continuous unit, or at the very least spanned a greater extent than what is now remaining, supporting previous interpretations of outlying deposits [5]. Olympia Planum's domed surface continues underneath and into PB in a smooth continuous transition with polar symmetry until contact with the high area discussed by [8]. This continuity agrees with predictions of prior studies [3-5]. However, the missing, elliptical section of BU in the 120° E to 150° E area near the BU edge is problematic as it cannot easily be explained via depositional processes. Once more, enigmatic erosion is responsible for BU morphology.

No clear constraint exists to quantify the time elapsed between the end of BU deposition and the start of NPLD deposition. However, SHARAD results allow estimation of volumetric loss from the BU. We know from MARSIS radar sounding results that the base of the BU is flat [2]. If an initial BU accumulation pattern with low gradients is assumed, one can estimate volumetric loss using the difference between current BU topography and a continuous surface projected across deviations.

As prior work suggests, much of the material lost from the BU may be responsible for Vastitas Borealis landforms including, but not limited to, dune fields. Accurate assessment of sediment influx into these systems, via BU erosion estimates and modeling, will likely prove valuable in determining the processes at work modifying the BU and the surrounding areas. The availability of a well-defined topography at the onset of NPLD deposition may also allow for a better understanding of what governed patterns of NPLD accumulation, leading to today's PB morphology.

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