THE BASAL UNIT: AN AMAZONIAN RECORD OF MARS' NORTH POLAR HISTORY S. Nerozzi[1], M. R. Ortiz[2], J. W. Holt[1] [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ (nerozzi@email.arizona.edu). [2]Jackson School of Geosciences, University of Texas at Austin, TX.

Introduction: The basal unit (BU) is a sedimentary deposit of water ice and lithic fines lying at the base of Planum Boreum on Mars [1-8]. It can be divided into two subunits, rupēs and cavi, on the basis of their stratigraphy and age [4, 6]. The BU lies between the Late Hesperian Vastitas Borealis interior unit and the Late Amazonian North Polar Layered Deposits (NPLD), and thus represents a record of polar geologic processes and climate events spanning most of the Amazonian Period [4, 6]. Despite the numerous recent studies, several key questions remain unanswered:

How are the different geologic units within Planum Boreum related? What is the full extent and volume of the rupēs and the cavi units? What is the geometry of the erosional unconformity between them?

What do the characteristics of the lower north polar ice deposits reveal about their formation and evolution? Which geologic processes and climate events are recorded in the morphology of the BU?

Ref. [8] hypothesized that the cavi unit is made of alternated sand sheets and pure water ice remnants of former polar caps. How many of these sheets are contained within cavi, and what is their extent? How was cavi constructed through time?

Methods: In this study, we integrate Shallow Radar (SHARAD) observations and high-resolution visible imagery to provide answer to the outstanding questions presented above.

Radar sounding. SHARAD is an orbital sounding radar with a vertical resolution of ~8.4 m in water ice [9]. The comprehensive and dense coverage of Planum Boreum with over 3000 profiles enables high-detail mapping of the surface topography and internal stratigraphy of the BU. We mapped the upper surface of the BU distinguishing three distinct radar reflectivity facies, which allow us to separate rupēs and cavi unit detections [7]: "sharp" return, typically associated with rupēs unit materials; "diffuse" return, typical of the cavi unit and dune fields; "mixed" return, interpreted as rupēs unit material with abnormal surface roughness and/or a thin veneer of cavi unit material.

High-resolution imagery. We integrate the analysis of SHARAD profiles with images acquired by the High Resolution Imaging Science Experiment (HiRISE; [10]). We use the nearly complete HiRISE coverage of BU visible outcrops to obtain a high-resolution (~32 cm/pixel) visual constraint of the BU topography and spatial distribution in Planum Boreum, and establish the type of contact between the cavi unit and the NPLD.

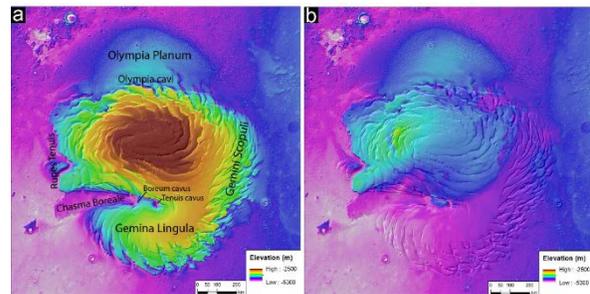**BU lateral extent:** Our mapping indicates that the

Figure 1: (a) MOLA elevation map of Planum Boreum. (b) MOLA and SHARAD elevation map of the basal unit and surrounding plains obtained in this study, with superimposed shaded relief of the modern Planum Boreum topography.

BU extends over an area larger than that delineated by the most recent radar studies [3, 5, 7]. We detected radar diffuse returns extending from the western edge of Gemina Lingula to Gemini Scopuli, covering an area of ~120000 km². The diffuse return reflector is followed by a second, deeper reflector, which is continuous with the Vastitas Borealis interior unit. Based on detection of radar diffuse signals and the continuity with the adjacent cavi unit, we interpret this packet of material as a previously undetected lobe of cavi unit. Assuming a lithic-rich mixture for the cavi unit with a relative permittivity of ε' = 4.84 [8], we obtain an average thickness of ~50 m. In Gemini Scopuli, this lobe extends beyond the edge of the NPLD, where HiRISE images reveal flat lying terrains forming terraces and characterized by sinuous and arcuate forms reminiscent of aeolian cross strata. These aeolian cross strata may pertain to aeolian forms in the cavi unit or remnants of more recent forms on top of it. These observations suggest that cavi unit materials, or their recent equivalent, are exposed in this region, thus corroborating the proposed detection of the BU of ref. [2]. The newly mapped extent of the BU reaches 890000 km², 37% larger than the most recent estimate [7]. Analysis of BU outcrops gives us a visible constraint on the lateral extent of the rupēs unit, which we detect only in the western half of Planum Boreum. At its easternmost locations, the rupēs unit is characterized by sub-horizontal meter to decameter layering with eastward slopes of <0.1°. These observations suggest that the eastern half of the BU is made up exclusively of cavi unit materials.

BU stratigraphy: SHARAD is capable of penetrating through the materials of the cavi unit to expose both internal and basal reflectors [8]. In this work, we continued the cavi unit mapping effort to reveal its internal architecture and a possible contact with the underlying rupēs unit. In the western half of Planum Boreum, we

identified a weak reflector underneath the diffuse return of cavi unit that is laterally connected to the sharp return typical of rupēs unit materials. This weak reflector dips gently towards the north pole and Chasma Boreale, similar to the rupēs unit sharp reflector and previous measurements [11]. Based on the continuity of this reflector with rupēs unit returns, its geometry and geographic location, we interpret it as the contact between the cavi and rupēs units.

Although SHARAD does not generally detect subtleties of the gradation between cavi and the NPLD, we did find evidence of a lens of isolated material located between the two units. The top of this deposit is a relatively sharp reflector, followed by a diffuse return and a reflection-free zone. This feature extends over an area of ~4000 km^2, and has a volume of over 300 km^3 assuming a water ice composition. We also found further evidence of the gradational and transgressive contact between the cavi unit and the NPLD at multiple outcrop sites. We interpret the lens of material located above cavi as a late episode of aeolian sand accumulation on top of cleaner water ice. Numerous occurrences of similar cavi-NPLD transitional features can be observed along visible outcrops in the outskirts of Planum Boreum. This is the first detection of such transitional deposits in radar profiles and provides new information on the potential three-dimensional size and geographical distribution of these features.

BU morphology: We identify several scarps in our BU morphology map. All but one scarp face southward, and some enclose low-lying reentrants. The two reentrants mapped by ref. [7] show significant morphological complexity that was not detected before. A series of elongated depressions tens to hundreds of meters deep appear along the edge of cavi unit. In some cases, the base of these depressions are flat and appear to continue as reflectors within and at the base of the cavi unit. The location and orientation of these depressions coincide with deepest reaches of a buried chasma observed within the NPLD [12]. SHARAD profiles crossing these features show a continuation of the angular unconformity from the NPLD to cavi materials, suggesting that the erosional event that carved the chasma is also responsible for the formation of the depressions. This morphological record gives us insight on the intensity of the erosional event that carved the chasma. Current age estimates and growth models for the NPLD favor a short duration of the erosional event, suggesting very intense resurfacing of PB that removed large amounts of water ice and lithic fines from the cavi unit in addition to carving a chasma in the NPLD.

The new details of BU morphology suggest a more complex resurfacing history than previously thought, likely characterized by an intimate interplay of polar ice growth and retreat. Ref. [7] advanced the hypothesis that impact crater armoring of the rupēs unit is responsible for the formation of the prominent rupēs unit topographic high centered at 95°E 85°N. However, we find no evidence of these impacts in the morphological expression of rupēs unit as detected by SHARAD and find several similar occurrences of equator-facing scarps buried underneath the NPLD. Thus, we advance an alternate hypothesis that the erosion of the rupēs unit is intimately connected to overlying polar ice cover. This process appears to be active to date, with resistant ice layers of the NPLD providing protection from erosion and limiting the retreat of the rupēs unit to the narrow exposures along steep scarps. Ref. [13] observed the lowermost NPLD layers pinch out onto the prominent rupēs unit topographic high, thus suggesting that poleward erosion of the unit was prevented by a water ice cover, in a manner similar to the current evolution of the Rupēs Tenuis scarps. This process may be responsible for the formation of the other southward-facing scarps identified in our morphology map, opening the possibility that these ridges record the past extent of the NPLD and/or more ancient ice caps.

Conclusions: This study provides new insights on the extent, stratigraphy and morphology of the BU. We find that the BU is significantly more extensive than previously thought, and demonstrate that radar profiles acquired by SHARAD can provide the necessary stratigraphic context to comprehensively study isolated outcrops with high-resolution imagery. We find evidence of the contact between the rupēs and cavi unit in the innermost region of PB, which will allow us to better constrain the relative volume of the two units, and thus their water ice and lithic sediment content. Detailed mapping of the BU surface morphology underneath the NPLD provides new insights on the major events in the erosional and depositional history of Planum Boreum.

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