SHARAD INVESTIGATIONS OF POSSIBLE LINKS BETWEEN EROSION OF MARS' PLANUM BOREUM BASAL UNIT AND NEARBY SEDIMENTARY DEPOSITS. T. C. Brothers[1] and J. W. Holt[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

Introduction: The Basal Unit (BU) of Planum Boreum (PB), Mars was once hypothesized to be a smooth, lobate deposit [1], the result of relatively uniform ice and sand deposition on the Martian north pole. Recent BU mapping [2-4] has unveiled many complexities, however. In addition to strong relief on the BU upper surface, newly revealed features can best be described as erosional cutbacks and reentrants, indicating a complex BU accumulation history.

These results correlate well with recently documented accumulation patterns in the younger North Polar Layered Deposits, namely hiatal surfaces riddled with unconformities [2]. Image-based mapping of the BU has revealed two distinct members, the Rupes Tenuis unit and PB cavi unit [2]. An angular unconformity divides these units, indicating a period of erosion within the basal unit stratigraphy [2]. These two units are not yet distinguished in radar mapping and will be collectively referred to here as BU.

Prior studies hypothesized that the BU was a source for the circumpolar erg sand [1,5]. While it is not yet feasible to quantify the full extent of BU erosion, we can map localized erosion and estimate the volume of material removed from specific regions. Two locations, Abalos Colles (AC) and Chasma Boreale (CB), best fit the criteria necessary for this type of volume assessment (Fig. 1). An additional locale exhibiting a large BU reentrant exists near Olympia Cavi, but has not yet been quantified due to site-specific radar complications.

The two regions reported on here are the AC reentrant and a reentrant adjacent to modern CB. Attempts have been made to explain the AC sand deposits [6,7], but have relied on assumptions with few constraints. In both studies the features and deposits were attributed to volcanic activity resulting in melting of PB ice, and the release of sand within. Of course, aeolian processes could be invoked if the sand deposits are older than thought (i.e., only BU was exposed). If we are to assume that erosion, via melting or wind, of the polar ice led to creation of the fan shaped deposit, the volume of material in the deposit should be similar to the volume of sand material contained in the missing ice.

Adjacent to the modern CB, a major BU reentrant heads poleward from the northern side of the chasma. This reentrant is oriented subparallel to Hyperborea Lingula (HL) and the deposits outside of CB. Recent mapping of PB's internal stratigraphy [8] indicates that these deposits are not the result of catastrophic outflow as previously hypothesized for the formation of CB [9] and therefore must be reinterpreted. BU topography from radar mapping provides additional information not available for these prior interpretations and can be used to explore the possibility of a genetic link between BU erosion and the morphology of nearby features.

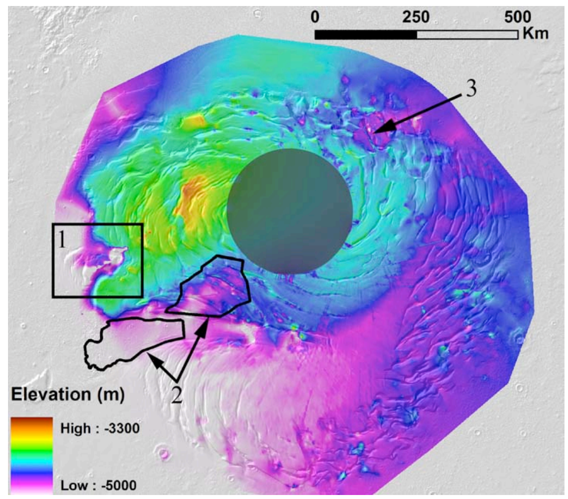

Fig 1: BU mapping results with semi-transparent MOLA hillshade. Boxes show context for (1) Abalos Colles, (2) reentrant adjacent to Chasma Boreale with outlines for HL sediment boundary, and reentrant itself (3) Olympia Cavi reentrant.

Methods: This study uses data from SHAllow RADar (SHARAD) aboard Mars Reconnaissance Orbiter (MRO) to construct maps of BU topography. SHARAD is an orbital sounding radar centered at 20 MHz with a 10 MHz bandwidth, resulting in a vertical resolution of ~9 m in water ice [10]. Additionally, MOLA elevation data is used to estimate the volume of material contained in the HL and AC deposits, material for which SHARAD is not able to detect a lower boundary.

As the goal of this project is to ascertain the likelihood of genetic links between BU erosion and nearby depositional features, it is necessary to quantify material lost from the BU as well as material contained within each deposit. This was done for both AC and the reentrant adjacent to CB.

To estimate the volume of material lost from the BU, interpolation of an upper surface was performed across the reentrants using boundary elevations not affected by the reentrants. This was accomplished within ESRI's ArcGIS™ mapping software. Interpolations were made using the nearest neighbor algorithm.

To estimate the volume of eroded BU material, the SHARAD-mapped BU elevation was subtracted from the interpolated upper surface. The result of this operation is a raster with thickness values for (presumed) lost material. Higher thickness values indicate larger amounts of removed material. Knowing both spatial extent and thickness, it is then possible to estimate the volume of missing material.

To estimate the volume of sediment in both the HL and AC lobate fans, a similar method was employed. A lower basal surface was constructed by extracting elevation values adjacent to each deposit. The resulting surface is a proxy for topography without each deposit. Thickness rasters were then created by subtracting the constructed basal elevation from MOLA elevations.

Results: Volume calculations for two reentrants and their associated deposits yielded different results (see table). While both contained similar eroded BU values the associated sediment volume is different by a factor of six.

	Eroded BU Ice (km^3)	Sediment in nearby features (km^3)	Sediment/ Eroded Ice (%)
AC	3383.39	522.8	15.45
CB	3654.46	3315.82	90.73

The AC region has a sediment to ice ratio of approximately 15%. This means that if all of the sediment present in the AC fan came from the eroded BU, the eroded BU would have needed to contain at least 15% sand by volume. While this number is high, it does not seem unreasonable based on observed sand layering in the nearby cavi unit [2,11].

The calculated volume of sediment in HL nearly matches the estimated volume of ice removed via poleward BU erosion. There are several possibilities that could explain this result. If HL contains material virtually identical in sand/ice ratio to the BU, this would be expected (however, a lack of SHARAD reflections in HL makes this unlikely). Furthermore, if HL has accumulated material from a multitude of sources, any one source would be insufficient. Other possibilities are that HL is a lower portion of the BU, the material removed from the BU in this reentrant is not related to HL, or that the reentrant feature in the BU is constructional rather than erosional, similar to CB [8].

Conclusions: Although both studied locations do not have the same sediment–to-eroded ice ratios, the

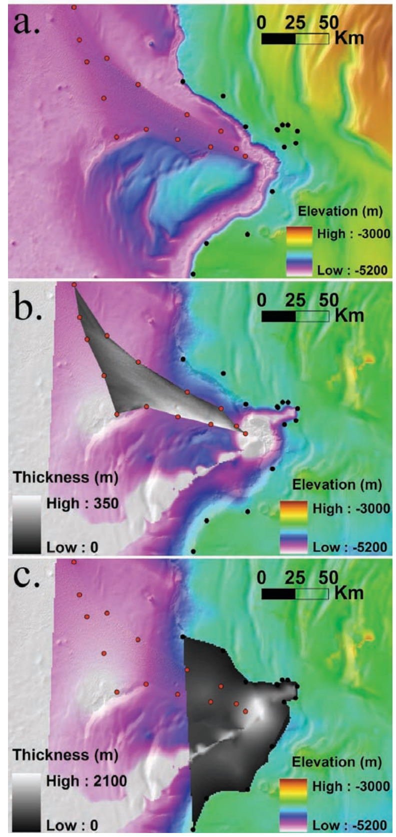

Fig 2: Illustration of methods used to create volumetric estimates.
a.) MOLA surface with point data containing elevation corresponding to surface top (Abalos ice, black) and surface bottom (sediment basal elevation, red)
b.) BU mapping results with sediment thickness raster overlain.
c.) BU mapping results with eroded ice material thickness raster overlain.

volume of sediment does not surpass the volume of eroded ice material in either case. If the volume of sediment had surpassed the volume of missing ice it would have indicated no genetic link could be made between these circumpolar depositional features and BU erosion, at least given current understanding. However, due to the observed relationships there is indication that the BU may in fact be the dominant source of material in some of the circumpolar erg.

The results of this study offer additional insight into the origin of circumpolar sediment deposits. The dune fields of AC show a positive correlation to nearby BU erosion while the HL example indicates unknown or poorly understood processes dominating morphology.

References: [1] Byrne S. and Murray B. C. (2002) *JGR*, 107, 5044. [2] Tanaka K. L. et al. (2008) *Icarus*, 196, 318. [3] Putzig N. E. et al. (2009) *Icarus*, 204, 443-457. [4] Brothers T. C. et al. (2010) *LPSC XLI*, Abstract #2590. [5] Fishbaugh K. E. and Head J. W. (2005) *Icarus*, 174, 444. [6] Garvin J. B. et al. (2000) *Icarus*, 145, 648-652. [7] Hovius N. et al. (2008) *Icarus*, 197, 24-38. [8] Holt J. W. et al. (2010) *Nature*, 465, 446-449. [9] Fishbaugh K. E. and Head J. W. (2002) *JGR,* 107, E001351. [10] Seu R. et al. (2007) *JGR*, 112, E05S05. [11] Herkenhoff K. E. et al. (2007) *Science*, 317, 1711-1715.