CHARACTERIZATION OF MARTIAN NORTH POLAR GEOLOGIC UNITS USING MARS ODYSSEY THEMIS DATA. K. E. Fishbaugh\textsuperscript{1}, \textsuperscript{1}International Space Science Institute, Hallerstrasse 6, Bern, Switzerland CH 3012, fishbaugh@issi.unibe.ch

\textbf{Introduction:} The north polar basal unit (BU), lying stratigraphically between the polar layered deposits (PLD) and the Vastitas Borealis Formation (VBF) has been hypothesized to be an Amazonian-aged, frozen deposit composed both of eolian material and material from ancient polar caps (smaller than the current cap) which have completely ablated [1]. Study of the origins of this unit [1-3] has led to important insight into north polar geologic history as a whole. Periodic migration of sand northwards from lower latitudes to create the layers of the BU may have been controlled by the formation and erosion of the ice-rich, low latitude mantling layer described by [4,5]. Additionally, possibly greater cumulative amounts of time spent at higher obliques during much of Mars’ past [6] may have contributed to the lack or smaller size of a polar cap during the time of BU formation. In this study, we begin an analysis of Mars Odyssey THEMIS data which lend further insight into the characteristics of this unit and its relationship with surrounding deposits.

\textbf{THEMIS IR Data:} We have begun preliminary analysis of THEMIS infrared data of the BU by comparing the relative differences in temperature between major polar features. The example in Fig. 1. was acquired during northern summer ($L_\odot = 116$) and encompasses PLD, a likely exposure of the BU, dunes of Olympia Planitia, and a few knobs associated with VBF plains. We have created the temperature map by converting the DN values of the IR image pixels to brightness temperature ($T_B$) using the calibration provided by the THEMIS team. While $T_B$ is not equal to the physical temperature, it is a reasonable approximation since most natural surfaces have an emissivity close to 1 at IR wavelengths. The temperatures (K) are put in 5-degree bins in order to highlight major variations.

\textit{Dunes and the Basal Unit.} It is immediately obvious that the dune-covered areas in Fig. 1 are relatively much hotter than the layered terrain and the knobs. This could be due to three main factors: the dunes have a relatively low albedo, the small grain size of the dunes may give them a relatively low thermal inertia [7] compared to ice-cemented materials, and the southward-facing dune slopes may be heated by the sun. Thus these dunes have been heating up all day; note that the local time ($\sim$18:00) is within daylight hours. Similarly, the scarp that contains a likely exposure of the BU is also quite warm as is the area at the scarp base, as warm in some spots as the dunes. Part of the warmth of the BU may be due to the fact that this is a south-facing scarp.

However, the temperatures may also be warm because the BU consists of material similar to that comprising the dunes. This could also argue for a relatively low ice content at least in the upper few microns to centimeters (the diurnal thermal skin depth) of the unit. We also find similar temperature relationships in THEMIS IR data between the BU and dunes within Chasma Boreale.

\textit{Polar Layered Deposits.} If we focus in more closely on the PLD in Fig. 1, we see that south-facing trough walls appear warmer than north-facing as evidenced by the orange and dark maroon banding. Flat areas on the surface of the ice appear the coolest. This relationship, however, is not immediately apparent in troughs within the Chasma Boreale region. Instead, it appears that the warm parts of the troughs lie on the flat areas just adjacent to the south-facing walls, and the main flat areas on the surface of the cap between troughs are not as easily distinguished in temperature from the troughs themselves.

In general, the PLD are cooler than the BU, possibly indicating that the two units have different thermal properties, which implies differences in such characteristics as grain size and ice content. Alternatively, albedo contrast may be the sole cause for the temperature differences. To test this, one can compare the temperatures of BU and PLD exposures with similar albedos.

\textit{The Polar Cap Surface.} All brightness temperatures of the polar cap surface derived thus far are above the CO\textsubscript{2} sublimation point of $\sim$150K indicating that all of the ice and frost is H$_2$O, as expected in the summer. Relatively warm spots appear in visible images to be covered in dust. During the daytime, the $T_B$ is above 200K which means that the potential for H$_2$O sublimation exists, though actual sublimation depends on many factors other than temperature (e.g. vapor pressure).

\textit{Other Features.} The bottom right corner of the image exhibits a feature in the plains which is as cold as portions of the ice surface. This is likely part of one of the remnant ice patches visible south of Olympia Planitia in image data. It is important to note that Fishbaugh and Head [8,9] have hypothesized that cap retreat may also have left remnants of ice (partially buried) in this area.

\textit{Temperature Changes over Time.} We have compared the temperatures of the BU, PLD, and dunes at different times of day at different locations. For this preliminary comparison, we assume that different outcrops of the same unit do not behave differently with respect to relative temperature change. The PLD
experience smaller diurnal $T_B$ changes than does the BU and thus may have a higher thermal inertia which could be related to containing more ice. For all units, diurnal $T_B$ changes completely overprint any $T_B$ changes due to the change in $L_S$ covered by these examples so that at least during this time ($L_S = 107$-147), diurnal $T_B$ changes are more important for polar processes.

**THEMIS Visible Data:** The example visible images which we have examined show dunes to be mostly bluish in color (e.g., Fig. 1). Likewise, the basal unit has a bluish tinge, indicating that it may consist of similar material to the dunes, as hypothesized by [1-3]. In contrast, the PLD appear reddish, consistent with the possibility that most of the particulate material in those deposits consists of the ubiquitous planetary dust [10] and likely has an overall different composition from the BU. Dark lenses within the PLD (an example of which is pointed out in Fig. 1), hypothesized by [1] to be trapped dunes which migrated from the eroding BU onto the newly forming polar cap, also appear bluish, like the dunes and BU.

**Conclusions and Implications:** The observation that the BU and north polar dunes are similar in temperature and color supports earlier conclusions, based mainly upon MOC and MOLA data, that the two features are made up of similar materials [1-3]. Since the polar layered deposits are clearly distinguishable in both temperature and color from the BU, it is possible that they have a composition and thermal properties different from the BU which is contrary to the conclusion that the BU may be an earlier, modified phase of PLD (Ap1 in [11]).

The polar troughs also show a complex temperature pattern, with the south facing wall not always necessarily being warmer than the north facing, having implications for trough formation models which partially rely on this relationship (e.g. [12,13]). The polar cap surface itself is heated by dust cover, as expected, and appears in the summer to contain H$_2$O as the only ice species. It is also possible that sublimation is occurring everywhere on the cap during the summer, creating a large ablation zone which must be considered when calculating mass balance for the cap. Also of relevance to calculations of mass balance and trough formation is the observation that during some parts of the year (e.g., the part of the year covered by this study) diurnal $T_B$ changes may completely overprint those due to changes in $L_S$.

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**Figure 1.** Top: Portion of MOC wide angle mosaic, MOLA shaded relief, and derived $T_B$ from THEMIS IR image 104626009 (Band 9, centered at 12.57 µm) taken from http://themis-data.asu.edu/. Image width is 32 km. South is towards the right. $T_B$ is in K. Middle: False color visible THEMIS image, V05036007. Blue = Band 1 (0.425 µm), Green = B2 (0.540 µm), and Red = B3 (0.654 µm). Bottom: V05413020, Blue = B1, Green = B2, Red = B4 (0.749 µm). Each band was separately contrast enhanced.