WATER-FREE LOW ALBEDO SURFACES IN PLANUM BOREUM, MARS J. A. P. Rodriguez[1, 2], K. L. Tanaka[3], Y. Langevin[4], M. Bourke[2, 5], J. Kargel[6], P. Christensen[7], and S. Sasaki[1] [1]National Astronomical Observatory, Mizusawa, Japan; [2] Planetary Science Institute, Tucson, Arizona, USA, alexis@psi.edu ; [3]Astrogeology Team, U.S. Geological Survey, Flagstaff, Arizona, USA; [4]Institut d'Astrophysique Spatiale, CNRS / Univ. Paris Sud, France; [5]Oxford University Center for the Environment, University of Oxford, Oxford OX1 3QY; [6]Department of Hydrology and Water Resources, Univ. of Arizona, AZ 85721, U.S.A; [7]Department of Geological Science, Arizona State University, Arizona, USA.

1. Introduction: Our examination of north polar day infrared summer mosaics, obtained by the Mars Odyssey's Thermal Emission Imaging System (THEMIS) in combination with a surface water map produced by spectral data obtained by the Mars Express' (MEX) OMEGA (Visible and Infrared Mineralogical Mapping Spectrometer) instrument, reveals the existence of four low albedo zones with a combined area of ~ 16 per cent of the total surface area of the northern polar plateau (Fig.1a), and which correspond to zones where the OMEGA instrument reveals the existence of extensive water-ice free surfaces (Fig. 1b).

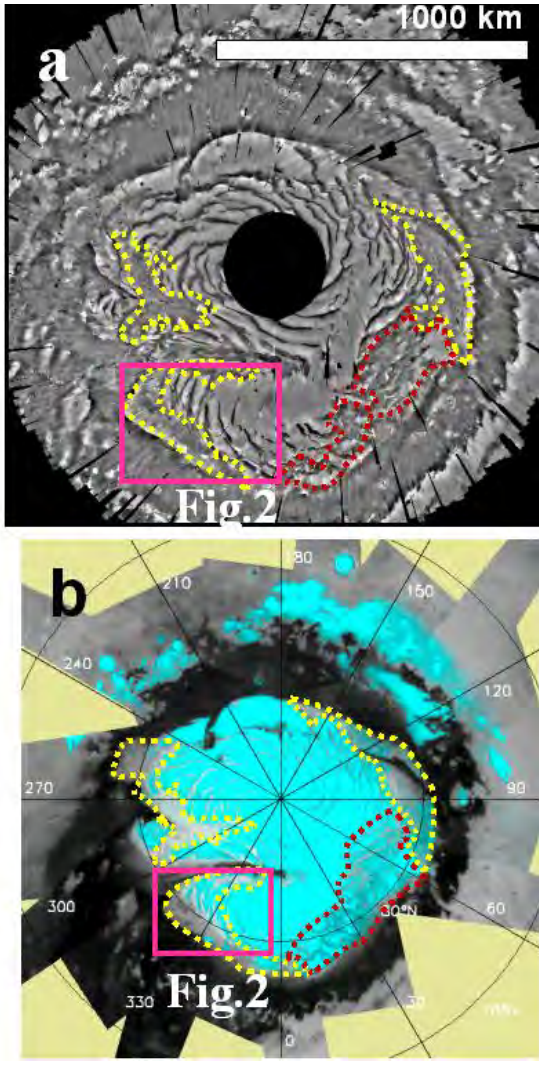

Fig. 1. *Views of the north polar region of Mars.* ***(a)*** *THEMIS visual-range mosaic of summertime images (at 32 m/pixel). Shown are four very extensive low albedo surfaces of Planum Boreum. Yellow dots outline surfaces of Planum Boreum that show an almost continuous low albedo, whereas red dots surround a surface of mixed albedo. (THEMIS mosaic provided by P.H. Christensen and the THEMIS Team, Arizona State U.).* ***(b)*** *False-color map of surface water-ice (cyan) detected by OMEGA. Water-ice is not detected in non-cyan areas. Yellow dots outline Planum Boreum surfaces that include large zones that are almost entirely free of water-ice, whereas red dots outline plateau surfaces where polar troughs display less water-ice than the plateau surfaces forming their margins, which commonly show diffuse water-ice signatures (tones of dark cyan). Zones enclosed by the red and yellow dots are approximately equivalent in panels* ***a*** *and* ***b****.*

2. Geology of south Planum Boreum: A plateau (inf., *south Planum Boreum*) southeast of Chasma Boreale includes two geomorphologically distinct zones. (1) A low albedo zone largely free of water-ice (Fig 1) and where polar troughs form well-developed systems. These polar troughs typically contain dark interior deposits that form the source regions of widespread systems of veneers [2] (Figs.1 and 2). (2) A higher albedo zone that forms the only extensive part of Planum Boreum, which is not cut by polar troughs. Instead, this zone, where the surface of the upper layered deposits (ULD) [1] consists of water-ice (Fig. 1), is marked by widespread undulations, which have a typical vertical relief of a few tens of meters (Fig. 2). We propose that veneers and the dark deposits within polar troughs from which they source, consist of water-free geologic materials that suppress the signature of surface water-ice. In South Planum Boreum ULD undulations typically extend from, or align parallel/sub-parallel to, polar troughs; in some cases, polar troughs that contain dark interior deposits occur along ULD undulations (Fig. 2). Removal of the dark interior deposits has resulted in the exhumation of the lower layered deposits (LLD) [1] materials, which form the floors of partly buried polar troughs. The difference in elevation between the surface of dark deposits and adjacent exhumed LLD that form the floor of troughs is ~100 m. Assuming that there are no abrupt changes in the elevation between the surface of the LLD that underlie the dark interior deposits and the adjacent exposed LLD trough floors, this value represents the local thickness of the dark interior deposits in these polar troughs. These observations suggest

that, at least in some polar troughs, the dark interior deposits represent exhumed geologic materials, which partly infill buried polar troughs located underneath ULD undulations. This hypothesis is further supported by the fact that in some cases, the ULD that form the surface of these undulations appear to have undergone localized degradation to expose lower albedo materials.

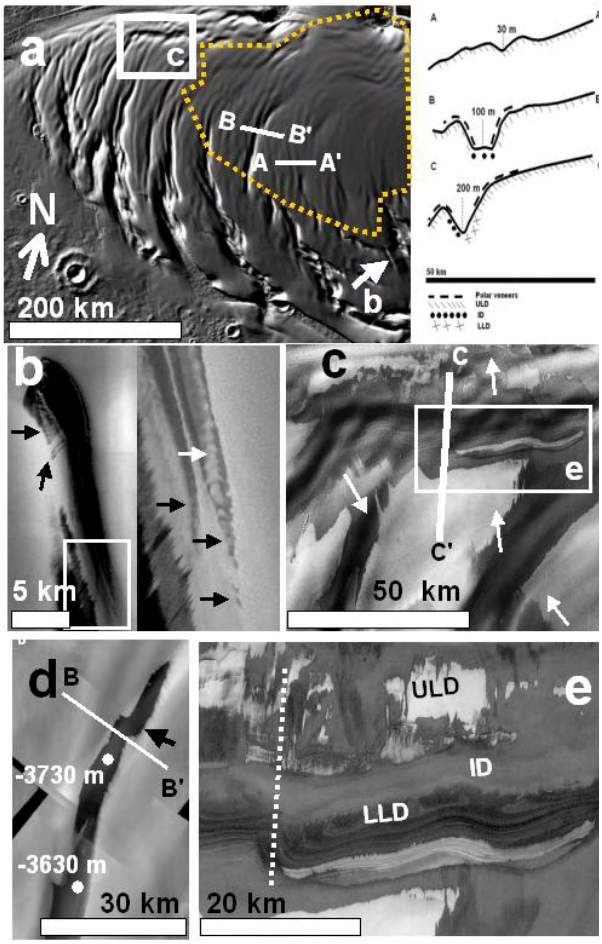

Fig 2. (a). *Regional shaded-relief view from MOLA DEM of southern Planum Boreum centered at 81.7° N, 340° E. Yellow dots outline a zone that corresponds in Fig.1 to a high albedo water ice surface. This terrain is marked by widespread systems of undulations (a few tens of meters in relief –elevation profile A-A'-) which extend from or are aligned parallel or sub-parallel to polar troughs that cut the surrounding lower albedo polar plateau surface, which is largely free of water-ice (Fig.1). MOLA extracted elevation profiles (A- A', B- B', C- C') are shown.* ***(b).*** *Left: Polar trough aligned parallel to undulations and contains dark interior material, which form the source regions of veneers (black arrows). (Part of THEMIS VIS 13274005 centered at 1.4° E, 80.3° N) Right: Close up of zone in the left panel outlined in box. Notice how differential ULD retreat appears to have resulted in the formation of surface grooves (black arrows) and a knobby ridge (white arrow). ULD retreat is possibly related to surface abrasion by the mobilization of ID particles into veneers and to enhanced insolation-driven sublimation produced by decreased surface albedo from veneer deposition (Part of THEMIS VIS 13506006).* ***(c)*** *Part of a THEMIS VIS summertime mosaic (18 m/pixel) superimposed on a MOLA-derived shaded relief image centered at centered at 327.5° E, 82.8° N. Low albedo surface largely free of water-ice situated in Southern Planum Boreum (see panel a for context). Notice how dense systems of north polar veneers (white arrows), which cover large expanses of plateau surfaces, have their source regions in a polar trough. MOLA extracted elevation profile (C- C') is shown in panel a.* ***(d).*** *Part of a THEMIS VIS summertime mosaic (18 m/pixel) centered at 344.6° E, 82.1° N. Enclosed trough, which is partly infilled with dark deposits and which terminates in a surface undulation (location indicated by B- B' elevation profile). The zone infilled with dark deposits has a relief of 100 m, and the adjacent trough floor is 100 meters deeper (white dots). These dark deposits constitute the source regions of dark veneers (black arrows).* ***(e).*** *Part of HRSC north polar mosaic centered at 327.9° E, 83.3° N. Location and context shown in panel c. Notice how the polar trough, which forms the source region for north polar veneers (panel a), is infilled with dark interior materials. Locally, the removal of ID materials has led to the exhumation of the LLD. In zones of LLD exhumation the vertical relief of the trough is 200 meters (elevation profile C- C'). The line of dots indicates the position of the elevation profile shown in panel c.*

3. Stratigraphic implications: Our observations indicate the existence of low albedo deposits that are interbedded between the LLD and the ULD (Intermediate deposits, ID). In our interpretation, ULD retreat was followed by the exhumation and transport of ID materials from polar troughs and eventually led to the deposition of widespread systems of north polar veneers, which we propose form the youngest stratigraphic unit in Planum Boreum, as well as to the exhumation of numerous polar troughs. Local exhumation of ID materials and retreat of the overlying ULD will be enhanced by the potential surface warming due to a decrease in albedo. This process would drive off interstitial ice and/or shallow buried ice. In addition surface abrasion produced by salting particles during veneer migration would also lead to net erosion. The stratigraphy in ice cores on Earth (dust and snow layers, bubble/air content, and stable isotope variations) is used to reconstruct paleoclimate. The assumption is that the dust and snow layers are airfall deposits, and that ice-trapped air is due to interstitial air contained originally in snow. However, it is known that surface melting events and other complexities can modify the primary stratigraphy in Earth's ice sheets and thus interfere with, or add, information relevant to paleoclimate reconstructions. We show that on Mars there may be significant endogenic sediment sources, and if these 'recent' episodes also happened in the past, then the observed layering may not all signify airfall events but may include some veneer deposits. This has important implications for the interpretability of PLD stratigraphy and of paleoclimate signals (e.g. [3]).

References. [1] Tanaka K.L. (2005), *Nature 437*, 991-994. [2] Rodriguez J.A.P. et al. (2006) *LPS XXXVII,* Abstract #1437. [3] Milkovich, S. M. and Head, J. W. III (2005). J. Geophys. Res. 110, E01005.