GEOLOGIC EVOLUTION OF MARS' NORTH POLAR LAYERED DEPOSITS AND RELATED MATERIALS FROM MARS ODYSSEY THEMIS. A. R. Vasavada[1], M. I. Richardson[2], S. Byrne[2], A. B. Ivanov[3], P. R. Christensen[4] and the THEMIS Team, [1]Department of Earth and Space Sciences, Box 951567, University of California, Los Angeles, CA 90095-1567, ashwin@ess.ucla.edu, [2]Division of Geological and Planetary Sciences, Mail Stop 150-21, Caltech, Pasadena, CA 90025, [3]Jet Propulsion Laboratory, Mail Stop 168-416, Pasadena, CA 91106, [4]Department of Geological Sciences, Arizona State University, Tempe, AZ 84287.

Introduction: The presence of a thick sequence of horizontal layers of ice-rich material at Mars' north pole, dissected by troughs and eroding at its margins, is undoubtedly telling us something about the evolution of Mars' climate [1,2]—we just don't know what yet. The North Polar Layered Deposits (NPLD) most likely formed as astronomically driven climate variations led to the deposition of conformable, areally extensive layers of ice and dust over the polar region. More recently, the balance seems to have fundamentally shifted to net erosion, as evidenced by the many troughs within the NPLD and the steep, arcuate scarps present near its margins, both of which expose layering.

Viking Orbiter imaging of the NPLD revealed that dark, dune-forming material is spatially associated with NPLD scarps [3]. This material may be liberated from an ice matrix by thermal erosion of the NPLD, either as sand particles or sand-sized aggregates of dust [4]. In either case, the NPLD seems to be a source of material similar in particle size and color to that present in the vast, circumpolar sand sea [3].

Recently, the stratigraphy of the NPLD has been subdivided into two unique units [5,6]. Outcrops of the upper unit are smooth and show many fine-scale layers. The lower unit consists of thicker, darker layers with an irregular, platy appearance. This stratigraphic sequence has been observed at widely separated locations within the NPLD [6]. If the layering is truly horizontal over the pole, such that the lowest portions of the stratigraphic column crop out in the marginal scarps, it suggests that the erosion of the platy unit uniquely contributes the dark, dune-forming material. Indeed, the platy unit may be an ancient sand sea now covered by the ice-rich, finely layered unit [6].

Optical and thermal infrared (IR) measurements have been used to infer and compare the properties of the different polar materials. For example, Thomas and Weitz compared the color of the dark material near NPLD scarps to material within NPLD layers and within the circumpolar sand sea [3]. Herkenhoff and Vasavada used Viking IR measurements to determine the nature of the dune-forming material and its relationship to other dark, dune-forming materials at lower latitudes [4]. However, such investigations have been limited by the relatively low spatial resolution of Viking color imagery and IR data compared to the spatial dimensions of layers, troughs, scarps, and dune fields. We hope to take advantage of the unprecedented spatial resolution of Mars Odyssey Thermal Emission Imaging System (THEMIS) visible and IR imagery in order to make these inferences and comparisons with the highest possible accuracy (e.g., Figure 1).

THEMIS Observations: To address this science goal, we defined a number of Regions of Interest (ROI) for THEMIS to target (Figure 2) as part of the Mars Odyssey Participating Scientist program. We gratefully acknowledge the THEMIS science team and operations staff for acquiring ~100 visible and IR image cubes during Mars' northern summer (L_s 110-160) as orbit tracks intersected our ROIs. The visible image cubes in our data set have five wavelength bands, along-track lengths of ~1000 pixels, and a spatial resolution of 19-38 m/pixel. The IR image cubes have ten wavelength bands and a spatial resolution of 100 m/pixel. The along-track footprint of the IR cubes often begins < 80° latitude, crosses the pole, and terminates < 80° latitude.

Planned Analysis: We will utilize these THEMIS data in order to understand the morphology and color/thermal properties of the NPLD and related materials over relevant (i.e., small) spatial scales. A first step will be to assemble color mosaics of our ROIs in order to map the distribution of ices, the different layered units, dark material, and underlying basement. The color information from THEMIS is crucial for distinguishing these different units (Figure 1), which are less distinct on Mars Orbiter Camera images.

We wish to understand the nature of the marginal scarps and their relationship to the dark material. Coregistered Mars Orbiter Laser Altimeter (MOLA) data will provide a measure of scarp morphologies and may help identify the process(es) eroding the NPLD (e.g., mass wasting, wind, sublimation). The dark material is present in continuous sheets at the feet of many scarps, but does not express dune bedforms there. However, dark material has barchan-type formations when present tens of kilometers away from the scarps [3]. MOLA will help identify the relationship between the spatial distribution of dark material, the presence of bedforms, and the influence of topography.

A more ambitious goal (probably beyond the timeframe of the 6th Mars Conference) is to derive the thermophysical properties of the different geologic materials using THEMIS and Mars Global Surveyor Thermal Emission Spectrometer (TES) data. Such analyses are complicated by the need for atmospheric correction (of both radiatively active CO_2 and dust) and accurate, representative surface temperatures. The latter may be compromised by the footprint size (compared to the areal extent of the material of interest), the influence of topography, and the absolute calibration of the measurement. However, the THEMIS data offer the promise of extending our previous analyses [4] to finer spatial scales and effort will be made to overcome these challenges. In order to derive thermal inertias and thermally derived albedos, we will employ a 1-D, radiative-convective thermal model of Mars surface, subsurface and atmosphere. The model will use simultaneous (or seasonally relevant) TES atmospheric dust opacities, and where possible, include the effects of surface slopes on insolation using MOLA topographic data.

References: [1] Murray, B. C. et al. (1972) *Icarus*, *17*, 328. [2] Cutts, J. A. (1973) *J. Geophys. Res*., *78*, 4231. [3] Thomas, P. C. and Weitz C. (1989) *Icarus*, *81*, 185. [4] Herkenhoff, K. E. and Vasavada A. R. (1999) *J. Geophys. Res*., *104*, 16,487. [5] Malin, M. C. and Edgett, K. S. (2001) *J. Geophys. Res*., *106*, 23,429. [6] Byrne, S. and Murray, B. C. (2002) *J. Geophys. Res*., *107*, 11-1.

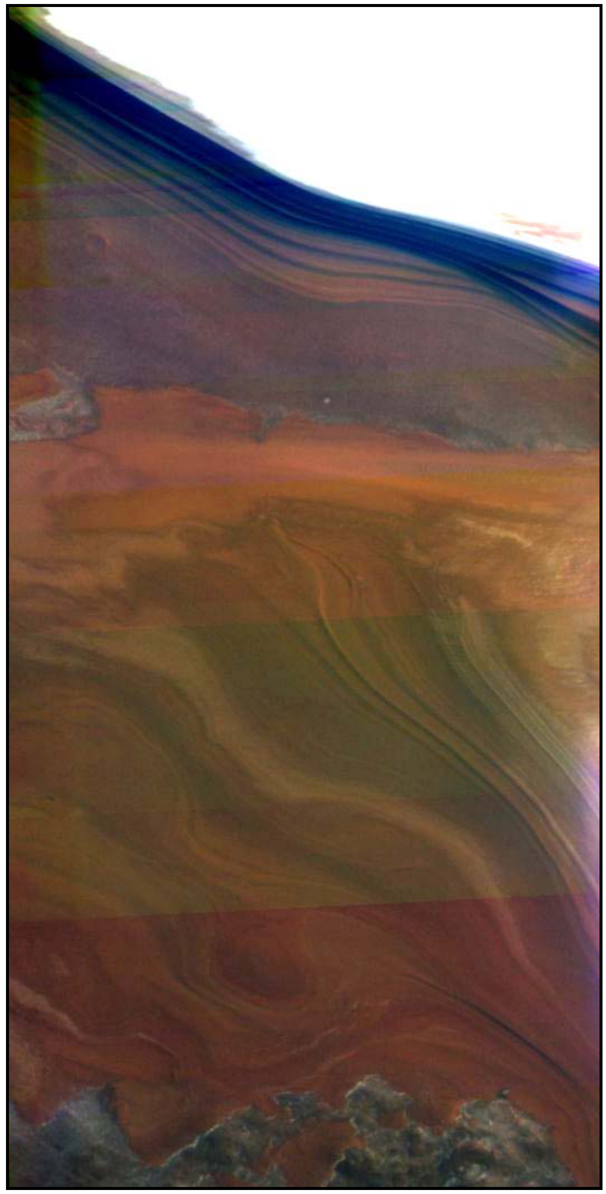

Figure 1. Color composite of THEMIS visible image data showing the north polar residual ice cap (top) and layered materials near the margin of the NPLD. Here the erosion of the deposits appears to “bottom out”, exposing the basement terrain underneath the NPLD (best seen along the lower edge of the image). The color information greatly aids this interpretation.

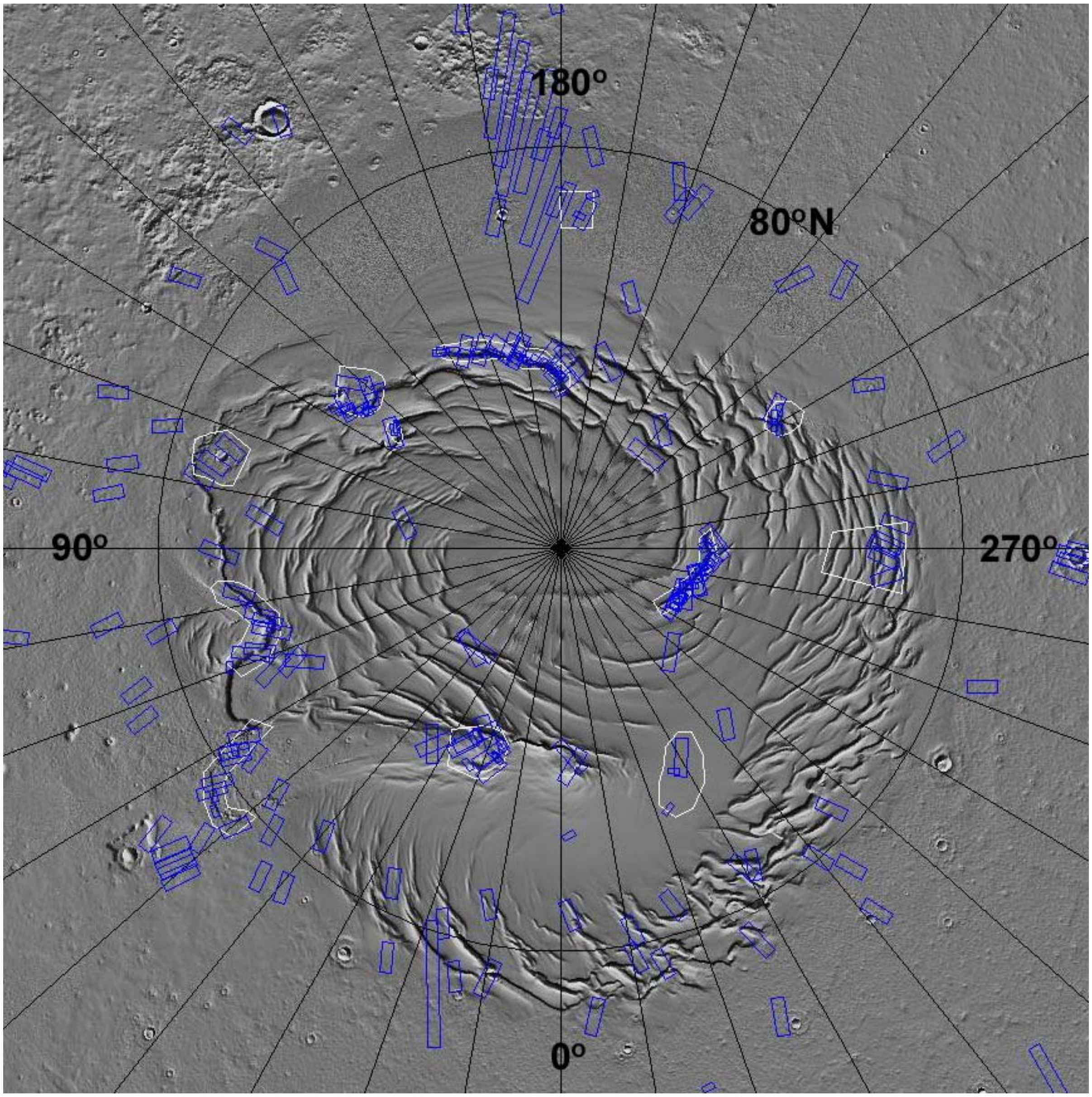

Figure 2. Map of Mars' north polar region showing the locations of our THEMIS ROIs (white outlines) and all acquired THEMIS visible image cubes (blue footprints). Our ROIs include arcuate scaps near the margin of the NPLD, the head of Chasma Borealis, and well-developed trough systems within the NPLD. The basemap is a shaded relief representation of Mars Orbiter Laser Altimeter data. Longitudes are West.