**Caltech SURF 2006 Research Proposal**

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# Martian North Polar Deposits Stratigraphy – Three Dimensional Characterization of Layers

## I) BACKGROUND

The North Polar Region of Mars comprises deposits of water ice and frozen $CO_2$, which form the layered terrain of this region, and are collectively called the Martian North Polar Layered Deposits (NPLD). Deciphering the stratigraphy of the Martian NPLD may provide critical insights into climatic processes on Mars. Instruments such as the Mars Orbital Camera (MOC) and the Mars Orbiter Laser Altimeter (MOLA) onboard the Mars Global Surveyor (MGS), as well as the Thermal Emission Imaging System (THEMIS) onboard Mars Odyssey, have produced large amounts of data pertaining to the Martian polar caps. Picking key elements of these data and studying them in detail can add to the understanding of the evolution of the Martian polar caps. The layered terrain in the NPLD is exposed in the Equatorward-facing slopes of troughs (V-shaped depressions) located throughout the north polar cap. Nomanbhoy (SURF 2003) et al. [1] utilized MOLA observations of the north polar cap to identify numerous offset troughs exhibiting lateral displacement across the entire NPLD. Following this, work done in SURF 2005 (Murray et. al. [2] & Pais et. al. [3]) focused on examination of small-scale variations in the stratigraphy of offset troughs over distances of 20 to 40 km. Interesting features of curvilinear 'wrinkle'-like layering exposed near the junctions of some offset troughs (e.g., Fig. 1) were observed. Such observations were hypothesized to represent evidence of localized ductile deformation within the NPLD. Detailed analysis of such wrinkled trough regions revealed specific departure from planar fitting in the vicinity of the offset troughs and raised important questions about the planarity of the layers.

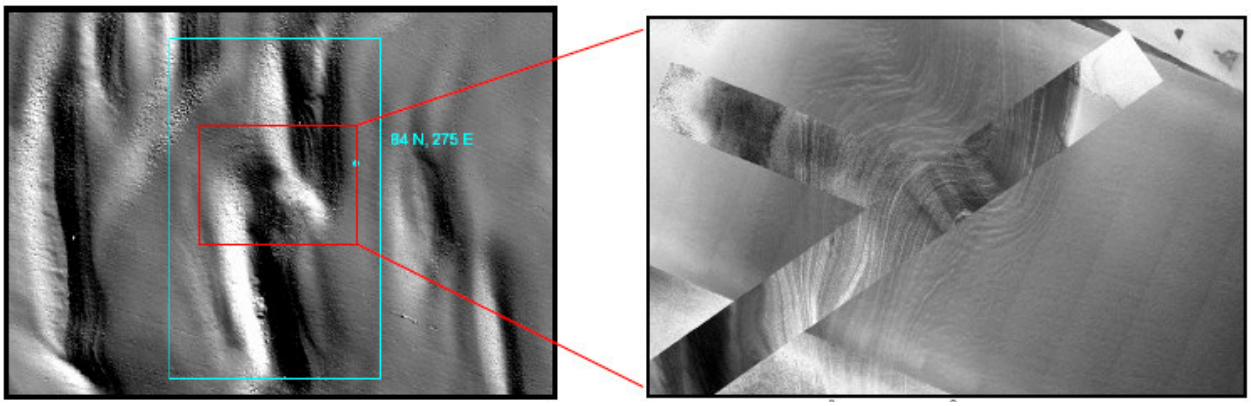


**Figure 1: WRINKLE EXAMPLE - MOLA Offset trough region A centered at 84°N and 275°E (Left) showing wrinkled layer stratigraphy at the offset in THEMIS and MOC images (Right). Red box highlights the offsetting location.**

## II) OBJECTIVES

A key result of the work done during SURF 2005 is that the wrinkle phenomenon seems restricted to offset troughs in the quadrant of the NPLD bounded by the 270°E and 0°E meridians. Additionally, planar approximations for layers in

these troughs show distinct deviations from the plane at the offset, in contrast to layers in simple straight-lying troughs that can be well-approximated with planar fits. This indicates either subsurface deformation or surficial erosion that appears to be localized in the vicinity of the offsets.

Numerous workers have attempted to statistically correlate PLD layers to predicted Martian orbital cycles (e.g., Cutts and Lewis, 1982 [4]; Laskar et al. 2003 [5]; Milkovich and Head, 2005 [6]; Fishbaugh and Hvidberg, 2006 [7]). For work in SURF 2006, we plan to extend the three-dimensional visualization techniques developed (E.g., Fig 2) for offset troughs last year, to other trough regions throughout the NPLD, in an attempt to statistically correlate layers in troughs. Additionally, we plan to undertake a systematic approach to stratigraphy analysis across the NPLD, particularly in an effort to correlate layers across different trough outcrops.

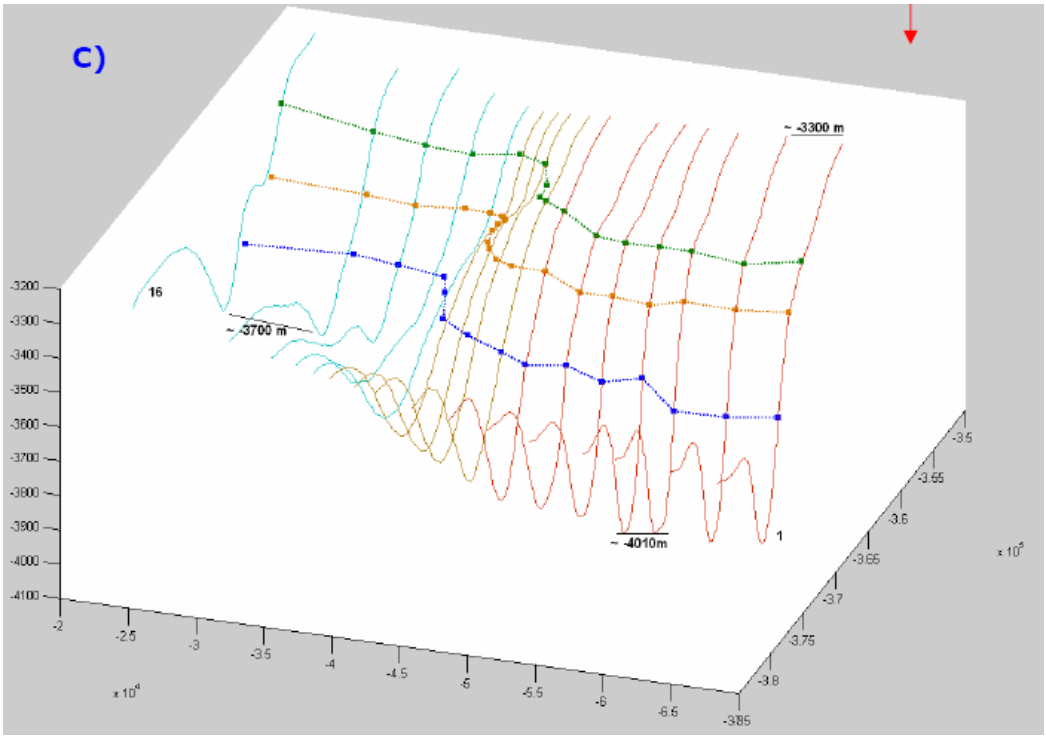


**Figure 2: 3-D Visualization example for offset troughs - SURF 2005**

In order to decipher the record of Martian climate change presumably encoded in the PLD, it is necessary to understand the processes responsible for layer modification. Hence, towards this end, we will incorporate the evidence for widespread layering into capwide models of PLD evolution involving such mechanisms as water ice sublimation, dust deposition, and glacial flow.

## III) APPROACH

Kolb and Tanaka, 2001 [8] identified pairs of adjacent troughs with similar layers as observed in MOC images. Subsequently, Milkovich and Head, 2005 [6] attempted to correlate trough layers statistically by a Fourier analysis method for MOC image layer data. Most recently, Fishbaugh & Hvidberg (2006 submitted) [7] have traced similar

layer stacks across troughs over relatively longer distances. In our approach, we will first conduct a cap-wide survey of exposed layering in troughs across the NPLD using available MOC, MOLA and THEMIS data projected as layers in the *ArcMap 8* GIS software package, paying particular attention to similar layers observed in the afore mentioned papers. We will then map specific layers outcrops in regions of the NPLD identified, in order to constrain the basic structure of the layered deposits. For this task, we will utilize three-dimensional reconstructions of trough MOLA data points in *Matlab*, as well as layer fitting analysis, in order to better understand and approximate the three-dimensional structure and orientation of the layered deposits across the NPLD. Finally, we hope to incorporate the evidence for widespread layering into capwide models of NPLD evolution in order to understand the processes responsible for layer modification.

## IV) ANTICIPATED OUTCOMES

A primary anticipated outcome is a better understanding of the nature and distribution of the layered deposits across the north polar cap of Mars. Further observations may indicate the reasons behind the complex wrinkled topography observed in our SURF 2005 work. Any evidence for widespread layering discovered (i.e. layers that can be correlated over large, capwide scales) could provide key constraints to models illustrating the processes behind such layer modification (erosion, glacial flow, deformation, etc.). Such outcomes would be valuable in drawing conclusion in the big picture – characterizing the past and current climate history of Mars. An important question arises when considering the layered structure of deposits in the NPLD- Can we account for the observed 'layer cake' geometry by simple erosion of a plane-parallel layer stack, or is there evidence of more complex deformational processes? We hope to answer this question using our three-dimensional mapping of layers across trough exposures and observations of layer geometry and thickness variations. This would be one of the core outcomes of this research work and will shed light on the processes that have resulted in the formation and modification of the NPLD.

## IV) REFERENCES


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