MODELING THE DEFORMATION OF LOBATE DEBRIS APRONS ON MARS BY CREEP OF ICE-RICH PERMAFROST.

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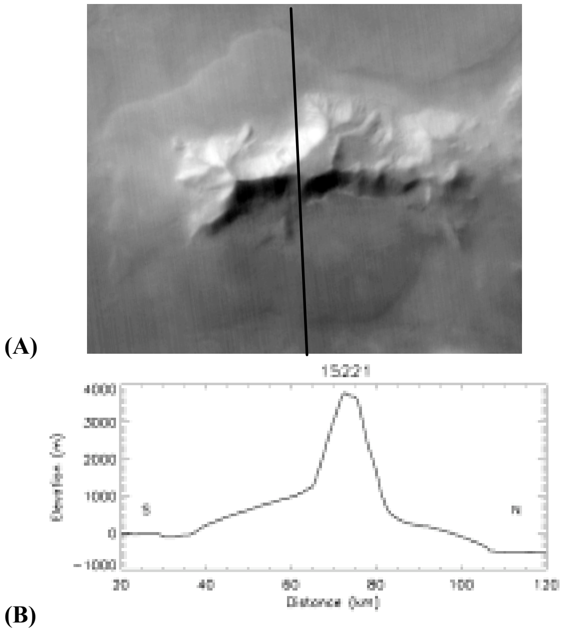
Introduction: A variety of mid- to high-latitude features on Mars has been attributed to viscous creep and flow phenomena associated with ground ice. Squyres [1] identified two classes of landforms: (1) softened terrain, resulting from *in situ* viscous deformation and particularly evident in degraded impact craters, and (2) debris aprons, produced by mass wasting along escarpments, *e.g.*, lobate debris aprons, lineated valley fill, and concentric crater fill. Such features have been attributed to kilometer-thick layers of permafrost within 200 m of the surface [2], an interpretation that is consistent with *Mars Odyssey* GRS observations indicating a high water content within ~1 m of the Martian surface [3]. We have documented the characteristics of softened landforms and debris aprons near Hellas using *MGS* MOC and MOLA data. By comparing the observed landforms to the results of finite-element models of viscous creep relaxation, incorporating recent laboratory measurements of ice/rock mixtures [4-6], we can constrain the conditions necessary to allow such deformation on Mars [7,8].

Observations: Debris aprons are broad, gently sloping (~1°-14°) accumulations of material at the bases of escarpments (*e.g.*, Fig. 1). They often exhibit convex-upward topographic profiles and relatively young crater retention ages (1-100 Myr). We have studied debris aprons east of the Hellas impact basin [9]: 30° - 40° S, 240° - 280° W. Using MOLA data we quantified a variety of attributes of mountains in the study region: latitude, longitude, maximum flank slope, total slope, total height, total width perpendicular to the long axis, and basal altitude. Within this region the only attributes that showed any correlation to the existence of debris aprons were latitude and slope, and these were not statistically significant. Despite a depletion of debris aprons in the part of the study area within Hellas (> ~270°W), no correlation with altitude was observed. We have expanded our study area down to 50° south to further investigate the effect of latitude.

Modeling: We have applied finite-element analysis to simulate the deformation of debris aprons by creep of an ice-rich surface layer. Our models incorporate the rheological parameters for dust/water-ice mixtures undergoing dislocation creep and grain size dependent creep [4,5]; both of which are relevant under present Martian conditions: $T_{surf} = 200$ K [10]; $dT/dz = 15$ K/km [11,12]. Our models have initial slopes ranging from 5° - 45°; slopes as shallow as ~1° have been observed for Martian debris aprons [13,9]. We find that final morphology depends strongly on the basal conditions and the initial distribution of ice-rich material. Even under present Martian conditions, viscous creep can occur quite rapidly, ~10^3-10^4 yr. However, if the ice were restricted by a resistant surface layer, the high volume fraction of ice inferred to be present within ~1 m of the surface [3] does not continue to significant depths, or large intact blocks are distributed within the ice-rich regolith [*e.g.*, 14], deformation timescales could be significantly longer.

Figure 1: Debris apron around a mountain near Hellas at 45ºS, 255°W. (A) MOC image (M0204416). (B) MOLA topographic profile (orbit 15221), vertical exaggeration ~10.



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