A comparative study of Martian lobate debris aprons to assess regional differences in surface properties, morphology, and internal composition.

E. I. Petersen[1], J. W. Holt[1], J. E. Berney[2]; [1]University of Texas Institute for Geophysics, [2]University of Texas, Bureau of Economic Geology

#2784

Introduction:

Martian lobate debris aprons (LDAs), interpreted as debris-covered glaciers [1], exhibit a longitudinal trend in radar properties in the region of Deuteronilus Mensae (figure 1). LDAs in the west generally exhibit strong, clear basal radar reflectors, while LDAs in the east exhibit weak or nonexistent reflectors. In this study we test for differences in LDA surface morphologies and internal properties which may play a role in determining radar signal losses through scattering and attenuation.

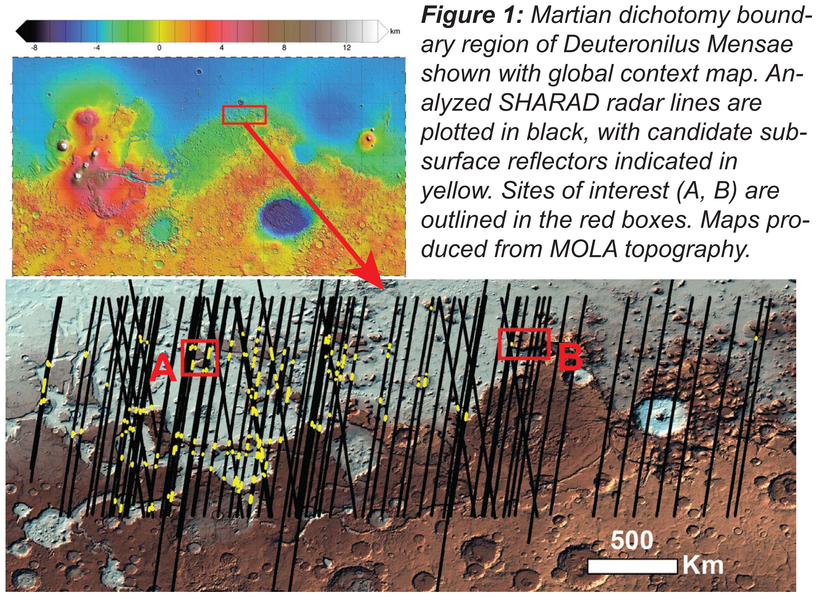
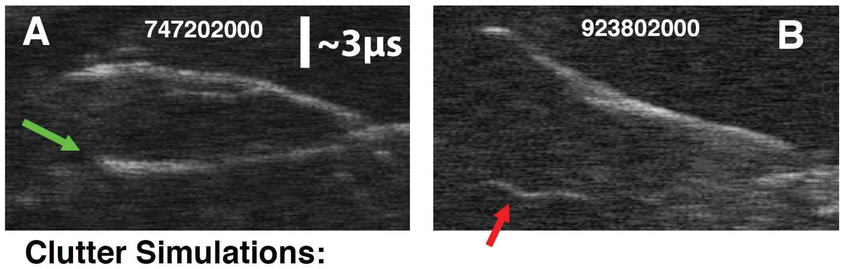
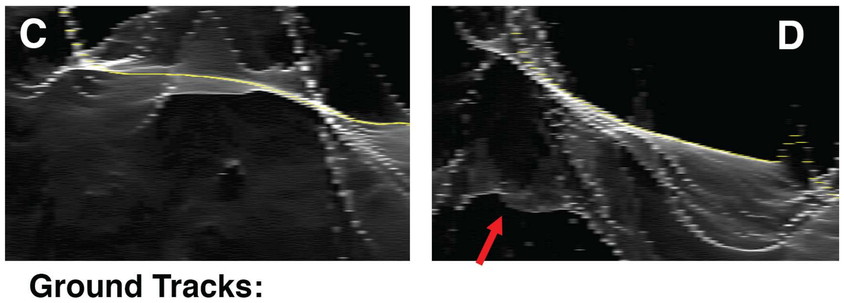


Figure 1: *Martian dichotomy boundary region of Deuteronilus Mensae shown with global context map. Analyzed SHARAD radar lines are plotted in black, with candidate subsurface reflectors indicated in yellow. Sites of interest (A, B) are outlined in the red boxes. Maps produced from MOLA topography.*

SHARAD Data:



Clutter Simulations:



Ground Tracks:

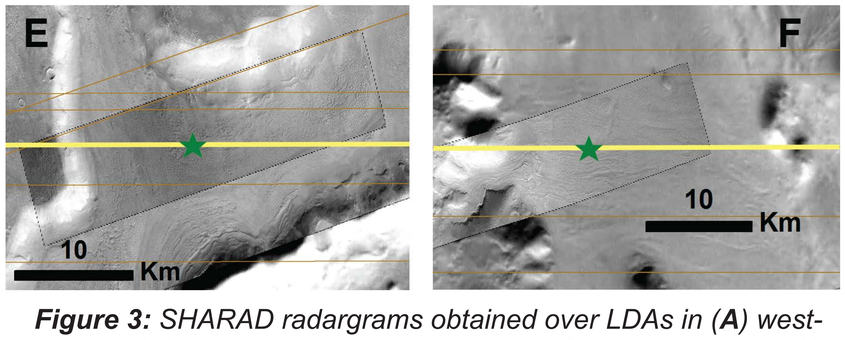


Figure 3: *SHARAD radargrams obtained over LDAs in (**A**) western and (**B**) eastern Deuteronilus Mensae. Clutter simulations (C, D) reveal that the subsurface signal seen in A is real (green arrow), while a portion of the signal in B is revealed as clutter (red arrow). Ground tracks (E, F) are mapped over LDA imagery, with north to the left and the location of the 2km-by-2km grid cells of geomorphic investigation indicated by green stars. Vertical (time delay) scale is the same for A-D, with 3 microseconds 2-way travel time corresponding to ~250m in water ice.*

Methods:

- LDA complexes in eastern and western Deuteronilus Mensae are selected as sites of interest.
- SHARAD data is analyzed in conjunction with simulated surface return radargrams ("cluttergrams") to distinguish between subsurface signals and surface echoes from off-nadir topography.
- 2km-by-2km grid cells of HiRISE imagery on each LDA surface are used to characterize the surface morphology of the LDAs to compare with SHARAD results.
- Flow-parallel topographic profiles are extracted from HRSC data to infer bulk dust-ice content from flow history.

Data:

- SHAllow RADar (SHARAD): chirped orbital radar sounder operating at 15-25MHz, corresponding to a vertical resolution of ~8m in ice. Along-track resolution of ~0.3 km and cross-track resolution of 3-6km.
- HiRISE visible imagery collected at resolutions of 25-50cm/px.
- High Resolution Stereo Camera (HRSC) digital terrain maps at 40-75m/px horizontal resolution.

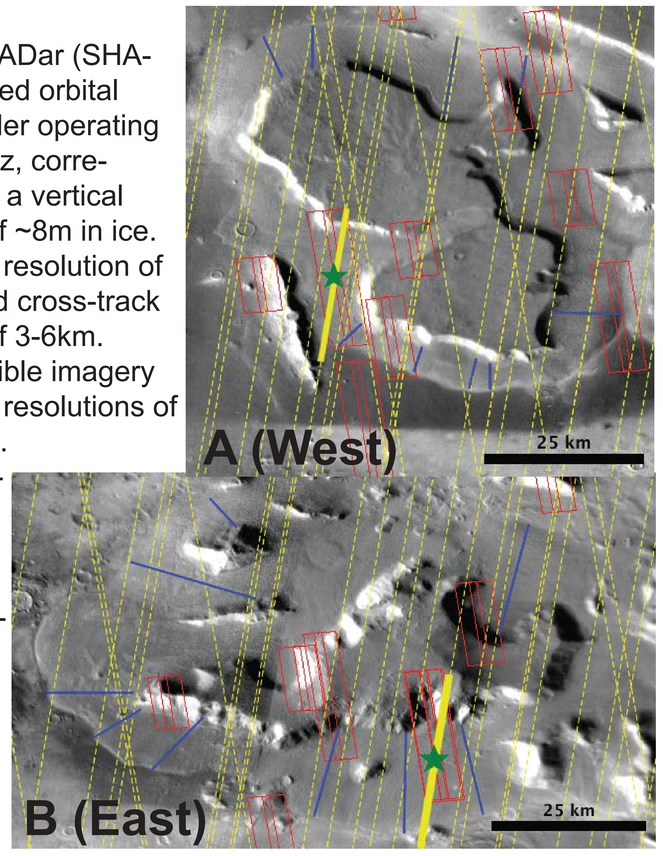


Figure 2: *LDA sites of interest in western (**A**) and eastern (**B**) Deuteronilus Mensae. SHARAD ground tracks are mapped in yellow while HiRISE image footprints are mapped in red. SHARAD data examined in detail are in bold. Green stars indicate location of 2km-by-2km geomorphically characterized grid cells. Blue lines indicate positions of extracted flowline topographic profiles. North is up.*

Topographic Results:

- The mean normalized profile from the eastern LDA complex was found to be generally less convex than that of the western LDA complex.
- This could be due to differing degrees of ice sublimation, or differing flow histories from different ice rheologies.
- Different ice rheologies imply differing dust-ice contents, a possible control on radar signal attenuation.
- Therefore, flow modelling studies [4] are of importance not only for shedding light on LDA flow history, but on radar interpretation as well.

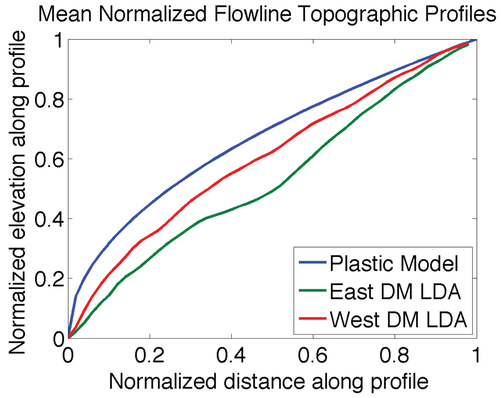


Figure 4: *Normalized topographic profiles from HRSC for the western and eastern LDA complexes plotted along with the results of a perfectly plastic ice rheology model, run to equilibrium [3].*

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Geomorphic Results:

- The eastern LDA exhibits widespread patches of "brain terrain," a unit resulting from differential near-surface ice sublimation [2] which produces high roughness at the scale relevant to SHARAD signal scattering.
  - Brain Terrain "Cells" are typically ~8-12m wide, ~4-6m high, and spaced at ~20-25m.
- While the western LDA surface exhibits some brain terrain, it is softened by polygonally-patterned mantle deposits
- Results on a single 2km-by-2km cell show the eastern LDA exhibits a higher percentage of high roughness terrain.

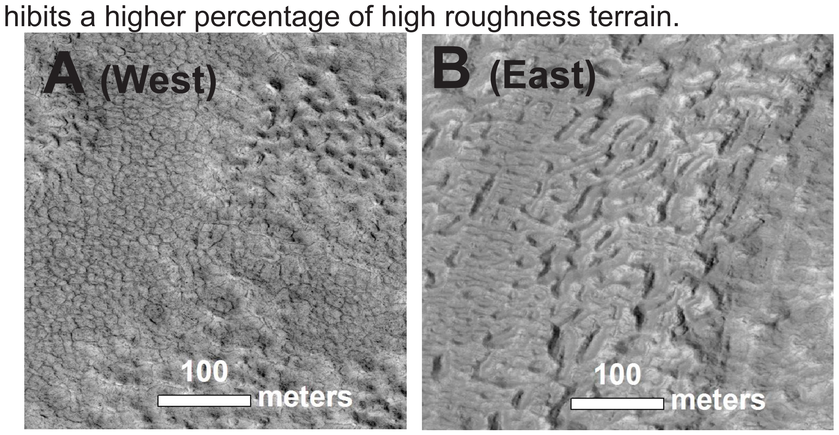
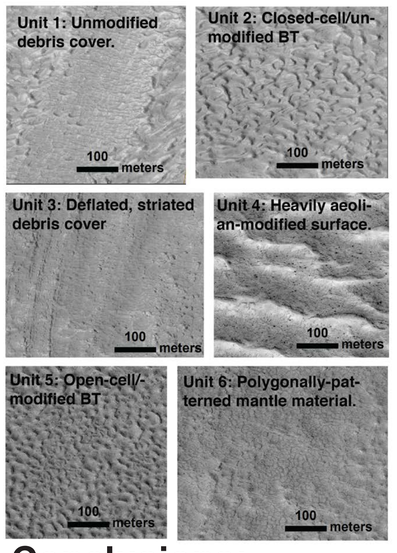


Figure 5: *Portion of HiRISE images collected over the (**A**) western and (**B**) eastern LDA complexes at a similar scale. Note the prominence of high-roughness "brain terrain" in B, and of low-roughness polygonal terrain in A.*



Western LDA:

- 88.5% Unit 6 (Polygons)
- 11.5% Unit 5 (Modified/smoothed Brain Terrain)

Eastern LDA:

- 68.5% Unit 3 (Deflated debris cover)
- 25.75% Unit 2 (Clear Brain Terrain)
- 5.75% Unit 1 (Unmodified debris cover)

→Over 2x the extent of brain terrain on the Eastern surface.

Conclusions:

1) Differing topographies imply differing dust-ice contents between the two LDA complexes.
2) Geomorphic characterization of two HiRISE images suggests a higher prominence of rough, radar-scattering terrain on eastern Deuteronilus LDAs vs. those in the west.

Future Work:

1) Flow modelling to constrain dust-ice content and compare to radar attenuation.
2) Wider regional geomorphic characterization and analysis of SHARAD surface returns for spreading due to roughness [5].

References: [1] Holt, J., et al. (2008), Science, 322, 1235-1238. [2] Levy, J. (2009), Icarus 202(2), 462-476. [3] Li, H., et al. (2005), Icarus, 176(2), 382-394. [4] Parsons, R., et al. (2011), Icarus, 214(1), 246-257. [5] Campbell, B., et al. (2013), JGR: Planets 118(3), 436-450.