QUANTIFYING ACCUMULATION PATTERNS IN THE UPPERMOST NORTH POLAR LAYERED DEPOSITS, MARS USING INTERNAL RADAR STRATIGRAPHY T. C. Cowan[1] and J. W. Holt[1], [1]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758 thomascowan@utexas.edu; jack@ig.utexas.edu

Introduction: The North Polar Layered Deposits (NPLD) compose much of Planum Boreum, a 1,000-km-diameter, 3-km-thick topographic dome that lies within the north polar basin of Mars (Fig. 1a). The layering visible in outcrop and within radargrams is believed to be the result of different proportions of dust and ice [1,2].

Previous attempts at characterizing the mass-balance and flow history of the NPLD of Mars have relied heavily on surface topography [3], surface imagery [4,5] and flow models [3,6]. Ice surface shape provides non-unique estimates of mass balance and accumulation patterns [5], and flow models have generally had to assume mass-balance patterns [3]. Internal stratigraphy can provide quantitative spatial variations of accumulation within the NPLD [5] that would provide much-needed constraints for climate and ice-flow models.

Here we show that accumulation has not been uniform over the NPLD, focusing specifically on a large, smooth lobe of material known as Gemina Lingula and its connection to the main lobe (Fig. 1).

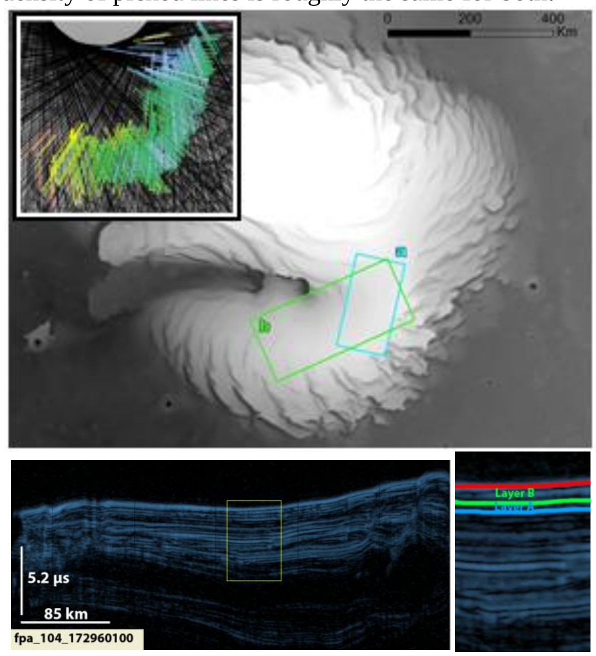
Data: New subsurface mapping efforts using the Shallow Radar instrument (SHARAD) aboard the Mars Reconnaissance Orbiter (MRO) enable fine-scale, three-dimensional quantitative data. SHARAD, with a 20 MHz center frequency and 10 MHz bandwidth, has a theoretical vertical resolution of ~9 m in ice and a horizontal resolution of 0.3 – 1 km along track, and 3 – 6 km across track [7].

Study Area: Gemina Lingula was chosen because radargrams from this area show low-slope, continuous reflectors which are relatively straightforward to interpret in data analysis software and contain minimal topographic clutter.

Methods: After choosing Gemina Lingula as the mapping region, several prominent reflectors in the upper 500 m were selected for mapping, using seismic interpretation software to interactively track reflectors across many intersecting ground tracks (Fig. 1b). Criteria for reflector selection included: (1) highly visible in radargrams, and (2) laterally continuous across the cap.

The positions of reflectors in each radar trace were exported and translated to latitude, longitude, and elevation coordinates by registering the surface echo to MOLA data, employing a cross-track-slope correction to the positioning and assuming a water-ice composition to determine depth below the surface [8]. Resulting vertical distances between the surface pick and each reflector were used to calculate layer thicknesses.

Fig. 1a shows the mapping extent of the two reflectors. Reflector a3 (blue) could be resolved over less of Gemina Lingula than reflector a2 (green) though the density of picked lines is roughly the same for both**.**



(a)

(b)

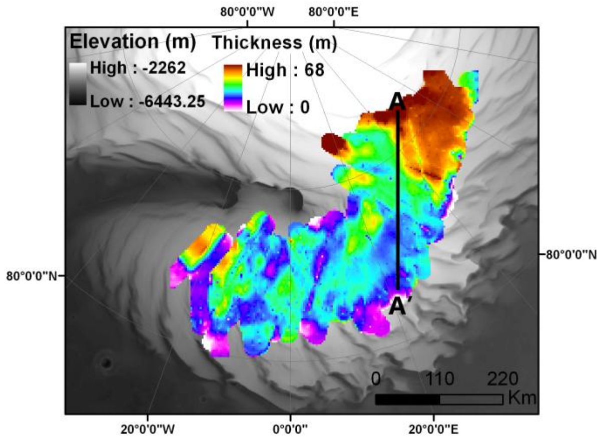
Figure 1: (a) *Location of mapping. Regions A and B show the extent for reflectors a2 (green) and a3 (blue) within Gemina Lingula. Inset shows total coverage.* ***(b)*** *Example radargram and zoomed section showing the location of layers B and A. 1μ is roughly 168 m.*

Difficulty in tracking some reflectors across all of Gemina Lingula may be caused by layers moving out of radar resolution [9] or simply thinning to zero thickness.

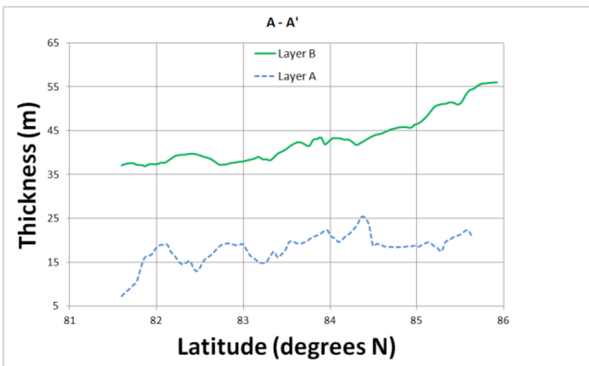
Results: Thickness maps created using ESRI's ArcGIS™ show that both layers are thicker towards the center and thinner towards the edge (Figs. 2a and 2b). This trend is most prominent between 15E and 70E.

The pattern of thickness changes for both layers is consistent. Layer A averages 20 m and is up to 46 m thick closer to the center of Planum Boreum. Layer B averages 45 m in thickness and is up to 76 m thick when approaching the center. The rate of thickness change is also larger at higher latitudes.

(a)



(b)



(c)

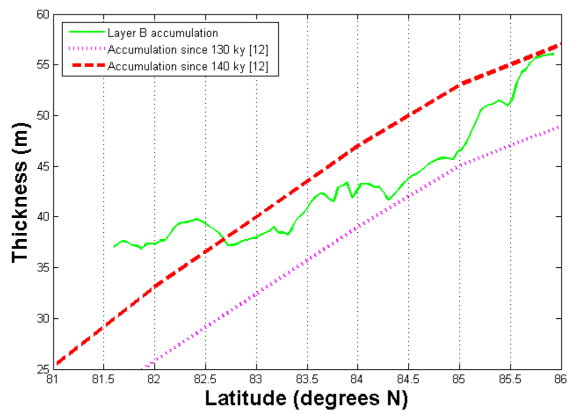


Figure 2: ***(a)*** *Thicknesses from the surface to reflector a2 (layer B) made using IDW interpolation in ESRI's ArcGIS™. Marked thinning of beds is apparent with decreasing latitude. Sections in map view showing zero thickness represent interpolation errors at the edges of the mapped areas.* ***(b)*** *Plots of thickness versus latitude show profiles from A-A' of both layer A and layer B.* ***(c)*** *Accumulation data from the MAIC-2 climate model [12] with observed trends. The figure shows that Layer B most closely matches modeled accumulation from 140 ky ago and 130 ky ago. It is important to note that thickness also increases with absolute elevation.*

Discussion: These results indicate significant variations in accumulation with latitude, and strong changes in just a few 10's of kilometers. Longitudinal variations do not appear to be as strong, at least within Gemina Lingula where the largest range of longitude can be evaluated.

Testing flow and climate model predictions and assumptions about accumulation patterns with observational data will refine our understanding of the mass-balance and flow history of the NPLD. Previous work [3,10,11] used terrestrial analogs to assume spatial patterns for flow models and determine the effect on internal layering. Radar-derived spatial patterns such as these would allow such models to be better constrained by using actual observations, and hence make better predictions.

A model of polar ice accumulation incorporating orbital parameters and atmospheric properties [12] predicts ice deposition and sublimation as a function of latitude, with a net accumulation of polar ice at the poles similar in volume to today's polar ice masses. From Figure 2 we can see that while latitude appears to be the dominant control on accumulation in the "saddle region" of Gemina Lingula (15E to 70E), more complex, possibly longitudinally dependant patterns can be seen between 15E and 20W. In addition, accumulation closely resembles the Greve et al. climate model. Future work will map more closely spaced reflectors or reflector packets deeper within the NPLD and will provide crucial constraints for the further development of models for NPLD formation linking orbital parameters to deposition and erosion.

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