

Basal Topography of the Martian Polar Layered Deposits:

A Comparative Study

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In the polar regions of Mars, there exist two formations of ice and silica dust denoted as the polar layered deposits (PLD). An understanding of the PLD is instrumental in unfolding Mars' climatic history. These deposits are of sufficient depth to hide the topography on which they lie; it is the objective of this study to estimate the bottom topography of the PLD by mathematically interpolating the trends of the surrounding terrain. This study, which was performed on both north and south polar regions, was used to determine the following: 1.) characteristics of the basal topography, 2.) volume of the PLD 3.) distribution/relative thickness of strata 4.) any correlation between surface and base topographies 5.) any sign of lithospheric flexure due to ice loading. With this, we are now better equipped to comment on the differences and similarities between the north polar layered deposits (NPLD) and the south polar layered deposits (SPLD) in each of these aspects. What we see from these results is that the NPLD and SPLD are more similar than would be suggested by their strikingly different location, elevation, and surrounding topography.

The entirety of our study was performed within the ArcMap 8.x software package.

Our approach to the study of the South was to measure elevations at the periphery of the SPLD (defined by ref. 2), and use selected interpolation techniques to estimate the basal topography. We used 1300 control points from the edges and areas surrounding the SPLD and included extensive control points from within the Chasmae and other features to fit a surface beneath the SPLD. No assumptions were made about any lithospheric flexure, nor did the results suggest that possibility. We first tested a variety of surface interpolation routines on a comparable area of cratered terrain immediately adjacent to the SPLD, using the same spatial distribution of 1300 height control points as we used for the SPLD itself, and found that the topography was broadly reproducible (ignoring craters) to within a few hundred meters.

Similar methods were used for interpolating the North polar layered deposits. First, a network of elevation samples was taken from the area surrounding the deposit boundary. We approximated the exact boundary (defined by ref. 3) by using a circle extending north of 78.5 degrees N latitude. Data point distribution extended from this boundary to a distance away that was equal to the deposits' total radius. Due to the smaller area covered by the NPLD and the surroundings area's less erratic topography, only ~800 samples were needed for the experiment. Also, a more even distribution of data points was employed in the North, where the long wavelength features were no better reproduced by increasing point density near the scarp of the deposits. Several different interpolation routines were tested, but were not found to generate surfaces that significantly affected the results of this study.

In order to accomplish this, we created a new shapefile, and then used the editor to create points or “features” on the map where necessary. After that, we converted the features to contain 3-dimensional data from the MOLA-derived 256 pixel/degree digital elevation model (DEM).

The ArcMap Geostatistical Analyst extension contains all of the interpolation routines and parameters that we used. As in the South, a local polynomial interpolation routine was used in the North. After generating the polynomial surface, we converted it into raster (or DEM) format. We then used a downloaded ArcScript to clip the interpolated raster to the outline polygon of the layered deposits. Using the raster calculator, we subtracted the basal topography from the surface topography to yield an isopach map. The spatial analyst calculated volume of the deposit, but because it contained some negative values, we did not use it to calculate the mean thickness of the ice. Instead, we divided the total volume figure by the area within the layered terrain boundary.

	Interpolation Routine Used	Calculated Total Volume (10 ⁶ km ³)	Volumes estimated by [ref. 4] (10 ⁶ km ³)	Area Covered By Deposits (10 ⁶ km ²)	Mean Depth of Deposits
North Polar Layered Deposits	4th degree 50/50 Local Polynomial	1.06	1.14	0.875	1.21
South Polar Layered Deposits	5th degree 50/50 Local Polynomial	1.09	1.20	1.36	0.80

I. Conclusion

a. We observed:

- i. Similar volumes of north and south
- ii. Very different basal topography
 1. north has long wavelength characteristic
 2. south is more erratic in nature
- iii. differently distributed ice masses
 1. mean depth

- iv. no indication of lithospheric flexure
- v. the thickest unit on both north and south are the polar-centric formations
- b. Total ice unit volume appears not to have been affected by elevation, topography, or location
- c. The thicker, more substantial unit of the SPLD conforms to the distribution pattern of the NPLD.
- d. The thinner unit of the southern deposits appears to be part of an older, eroded section. This may be because they lie beneath an unconformity in the strata.
- e. The Martian lithosphere is either compensated for or unaffected by the weight of the polar layered deposits.
- f.

Interpolated topography of the North and South polar layered deposits

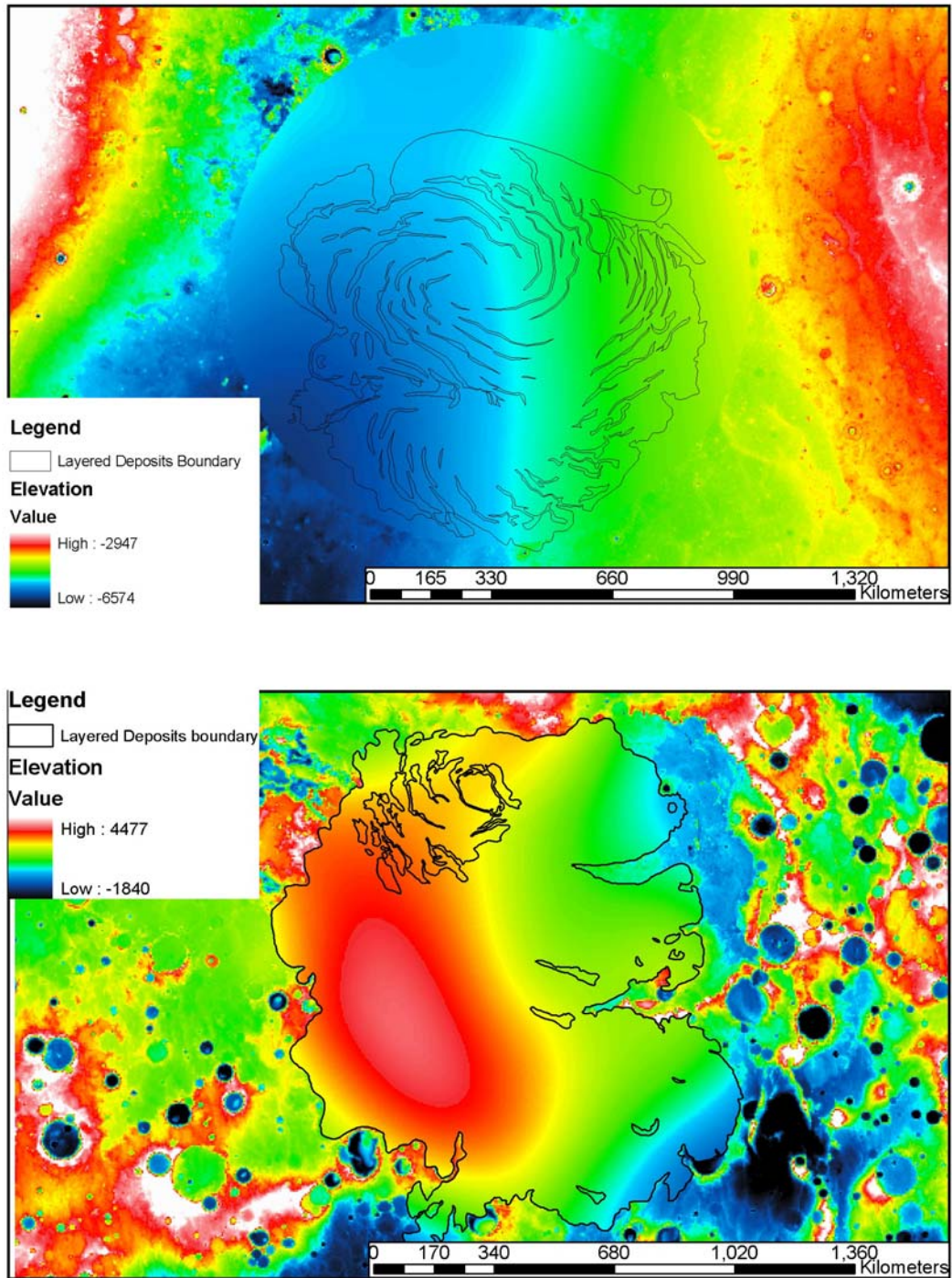


Fig. 1 These topographical maps represent the terrain in the polar regions that is covered by layered deposits. The areas outside of the layered deposits boundaries are from the MOLA gridded data. The areas within the boundaries are the interpolated bottom topography. The NPLD [top] is characterized by a very

smooth surrounding and underlying terrain. The SPLD [bottom] is characterized by a more significant set of subsurface features.

Approximate depth of the North and South polar layered deposits

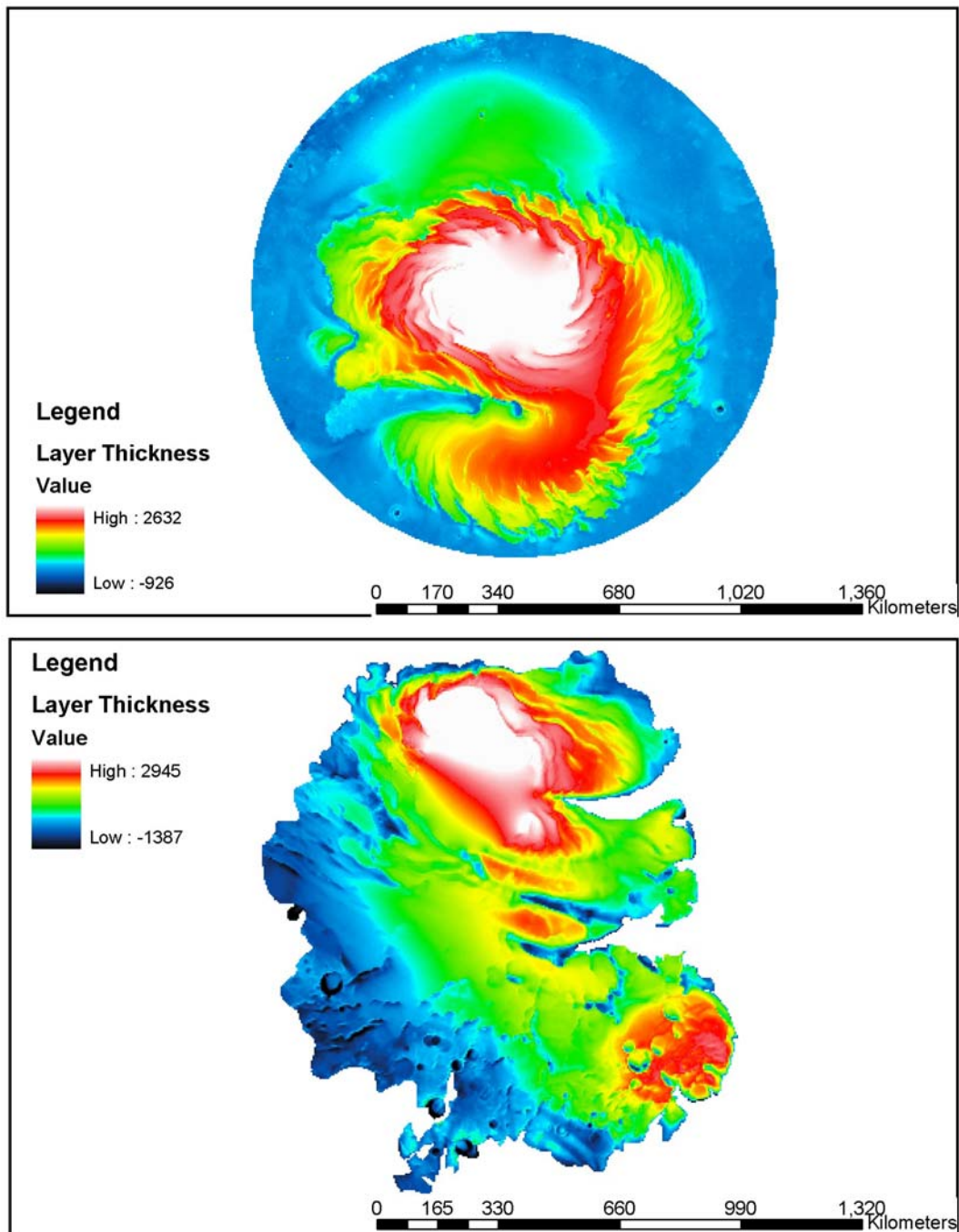


Fig. 2 the North [top] and South [bottom] PLD have distinctive distribution patterns. Although that both contain a similar volume of layered material, the NPLD is more evenly distributed over its area, which is much smaller than the SPLD.