THICKNESS ESTIMATE OF ICE-RICH MANTLE DEPOSITS ON MALEA PLANUM, SOUTHERN HELLAS BASIN, MARS.

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Introduction: Latitude-dependent ice-rich surface deposits of dust have been observed to mantle the middle and high latitudes of the Martian surface [1, 2]. These deposits often display unique surface modification in the form of dissected mantle terrains (DMT), interpreted to be the result of a loss in interstitial ice due to sublimation [3]. In previous work regarding the distribution of scalloped terrain, a type of DMT, it was observed that the mantle deposits on the southern wall of the Hellas Basin appear significantly thicker than those on Malea Planum [4]. This interpretation was based on the observation that craters on the wall of the basin are more heavily mantled, and in many cases completely buried by mantle deposits. Further investigation showed that, while present, the mantling on the plains of Malea Planum appears much thinner, and does not display the degradation features found on the wall of the basin [4]. In the present work, we have attempted to quantify the thickness of the mantle on the southern wall of the Hellas Basin and on Malea Planum using the measured crater diameter/rim height relationship of partially and completely buried 'ghost' craters. This method has been successfully used in the past in estimations of mare lava thickness on the Moon [e.g., 5, 6], flood lavas on Mars, [e.g., 7] and with dust mantles on Mars [e.g., 8, 9]. Because the dust-ice mantles represent a significant reservoir of presumably H_2O ice, quantifying their volume is important for understanding the current ice budget of the planet, as well as current and paleoclimate regimes.

Data and Methods: The study region is located on Malea Planum and the southern wall of the Hellas Basin from ~56°E to 70°E and ~52°S to 70°S. High Resolution Stereo Camera (HRSC, 12.5 m/pxl resolution) and Context (CTX, 5 m/pxl resolution) images in this area were examined for mantled impact craters. Where craters appeared to have been completely buried by mantle deposits, or where their crater rims appeared to be just barely visible through the deposit, their crater diameter was measured, and their location recorded. Crater rim heights (the expected average height of the crater rim above the surrounding plains elevation [9]) were calculated from these diameters using the relationship for simple craters of $h=0.04D^{0.31}$ from Garvin et al. (2003) [10]. This relationship was chosen because all measured crater diameters are less than the 7 km diameter transition point between simple craters and complex craters (measured crater diameters range from 0.081km to 5.8 km), and because specific target properties that effect diameter relationships are not known. In the region, 3829 craters were found to be mostly or completely buried. A gridded isopach map (Fig. 1) was produced using GMT software based on the calculated rim heights, with blues representing the thinnest calculated values, and reds representing the thickest. The method required that certain assumptions be made regarding the craters: 1) Craters are simple, bowl-shaped, and unmodified; 2) Craters formed prior to the emplacement of the mantle; 3) Craters are entirely buried or their rims are barely discernable from the surrounding terrain.

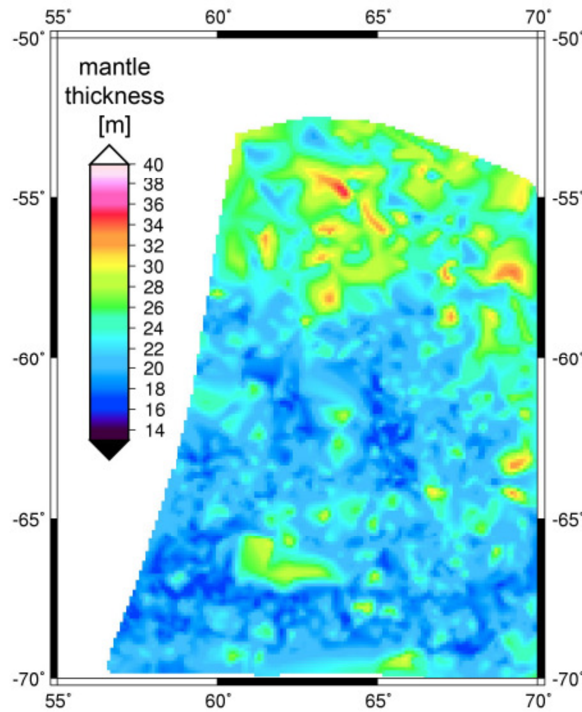

Figure 1: Interpolated isopach map of ice-rich dust mantle thickness on Malea Planum and the southern wall of the Hellas Basin. Mantle thicknesses range from ~13 m (blue) to ~39 m (red). The basin slope begins at around ~58°S, exactly where the thickness begins to increase.

There are a few caveats associated with our study. Specifically, we do not take into account any possible degradation of the crater rim in the time after the impact, but before any deposition. Also, we do not account for impacts that may have formed on pre-existing mantle deposits that were subsequently buried by later depositional phases. Using this method, caution has been exercised for the following reasons. Craters that are completely buried by mantle material probably represent an *underestimation* of the total thickness of the deposited material, as the thickness of the overlying material is not known. Additionally, if any given impact occurred after the deposition of mantle material began, the calculated depth would not be consistent with the depth to the basement surface, and would be an *underestimation* of total mantle thickness at that point. Complicating the estimations further are craters that are not completely mantled to their respective rims. For these examples, the calculated rim height would represent an *overestimation* of the amount of mantling material, and the difference between the crater rim and mantle layer should be subtracted. However, in many instances this is not possible due to the small size of the craters and the spacing of individual MOLA measurements. Resolution and atmospheric effects that influence image quality are additional sources of error. Many of the problems with these assumptions have been noted by previous researchers [e.g., 7, 9-12].

Results and Discussion: Mantle thicknesses derived from crater rim height calculations in our study region range from ~13 m (Fig. 1, blue) to ~39 m (Fig. 1, red). The thinnest areas of mantle are found on the highland plains of Malea Planum, with isolated areas of thicker smooth mantling, and some areas where dust has accumulated in topographic lows. The interpolation in the isopach map overestimates mantle thickness in thin areas where no data points were collected. Consequently the mantle is not a uniformly thick 13 m deposit, and visual inspection shows that the mantle is in some places can be thinner than indicated by the isopach map. The thickest areas of deposited material are found on the southern wall of the Hellas Basin. Craters in this area are often completely mantled so no crater rim is seen, and were identified by concentric fractures in the mantle material which mark the approximate outline of the buried crater rim. As noted before, the distance to the rim in these examples is unknown, and values are underestimations of the true thickness of the deposit. Mantle in these regions is typically smooth and continuously seen draped over the topography.

Evidence for significantly thick deposition overlying these buried craters can be seen in degradational features in the mantle. The depth of some scalloped depressions, measured with MOLA tracks, found overlying some buried craters, suggests that some craters are buried by 10 m or more of material. These sublimation landforms are not seen in areas of thin mantle on the highland plains. Our isopach map (Fig. 1) also shows a distinct boundary between areas of relatively thin mantling on the highland plains and relatively thick mantling occurring north of ~58°S, almost exactly where the break in slope of the Hellas Basin occurs. This relationship is clearly seen in Fig. 2, where the blue line represents the average MOLA elevation of the study region, and the red line the mantle thickness, both values averaged across the given latitude in the study region. Isolated areas of thick mantle appear as peaks in the plains areas of Malea Planum south of ~58°S. North of this latitude, the mantle thickens abruptly with increasing depth in the basin, and at elevations deeper than 0 m, the mantle is on average more than 5 m thicker than on the plains.

Conclusions: Our results indicate a distinct thickening of ice-rich deposited material on the southern wall of the Hellas Basin, compared to the highland plains of Malea Planum. The mantle on the plains is probably thinner than what is indicated in Fig. 1 due to the overestimation of values caused by partially buried craters. Similarly, the mantle on the slope of the basin is probably thicker than represented due to the complete burial of many craters and the underestimation of values there.

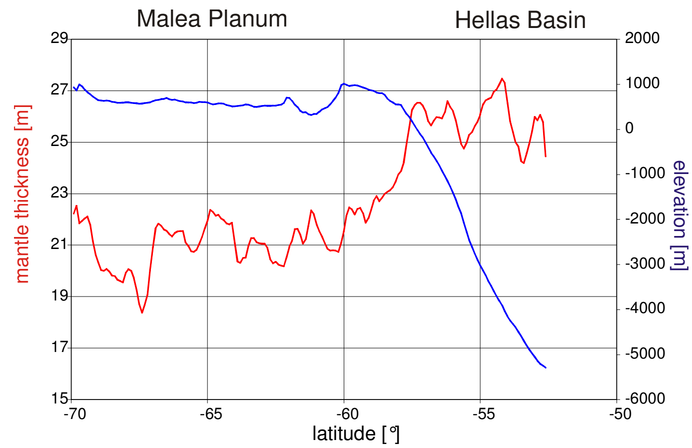

Figure 2: Averaged MOLA elevation profile across the study region in blue. Averaged mantle thickness across latitude of the study region in red. X-axis is latitude.

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