**DETERMINING THE FILL THICKNESS AND DENSITIES OF MARS' NORTHERN LOWLANDS.** Y. Tewelde and M. T. Zuber, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA (yodit@mit.edu).

**Introduction:** One of the most distinctive features of the Martian surface is the dichotomy between the heavily cratered southern highlands and the relatively smooth northern lowlands (Figure 1), the latter of which has been proposed to have formed in response either a giant impact [1] or mantle convection/overturn [2]. The northern lowlands appear smooth because many of the craters in the north have been partially or completely buried beneath volcanic and sedimentary fill of unknown relative proportions. With the use of the Mars Orbiter Laser Altimeter (MOLA) topography data [3, 4, 5], it is possible to map these Quasi-Circular Depressions (QCD) [6] or ghost craters and estimate fill thickness. We then estimate the gravitational attraction associated with the fill load from the Mars Reconnaissance Orbiter (MRO) gravity data [7] and, using the approach of Wieczorek and Phillips [8], solve for the density contrast required to fit the estimated depth of the basal relief interface.

**Methods and Results:** We use the MOLA topography map (Figure 1) [3, 4] to identify the location and diameter of 208 QCDs whose rims have been preserved. Garvin [9] performed a study on the global scaling relationships for all non-degraded craters on Mars adequately resolved by MOLA and determined the following relations:

$$\text{Simple: } d = 0.25D^{0.65}(D < 7km)$$

$$\text{Complex: } d = 0.33D^{0.53}(7 < D < 70km)$$

$$\text{Basins: } d = 3.5D^{0.017}(D > 70km)$$

where $D$ is the rim crest diameter (km) and $d$ is the fresh crater depth from rim crest to floor (km). Our study excludes craters with diameters $\leq 20$ km, as only complex and basins were used. Based on the fresh crater depths we linearly interpolate a prefill surface to estimate fill thickness throughout the northern plains region and treat this surface as a layer of basal relief. As can be seen in Figure 2, the average fill thickness in the northern plains is approximately 2 kilometers. This represents a lower limit given the methodology. We then use the gravity data to constrain fill density.

For such a large region it is best to perform the gravity analysis in the spherical harmonic domain, since the Cartesian domain would result in large errors due to the curvature of Mars. Using the latest MRO gravity model [7] and topography [3, 4] along with an estimation of basal relief, we can use the approach of Wieczorek and Phillips [8] to determine the density contrast required to produce the observed potential anomalies in the northern lowlands.

By removing the geoid contributions of the topography and Moho from the observed geoid, we isolate the geoid height associated with the interface between the fill and the crust. We then solve for the density contrast required to match the estimated depth of the basal relief interface. The results of the density calculation can be seen in Figure 3.

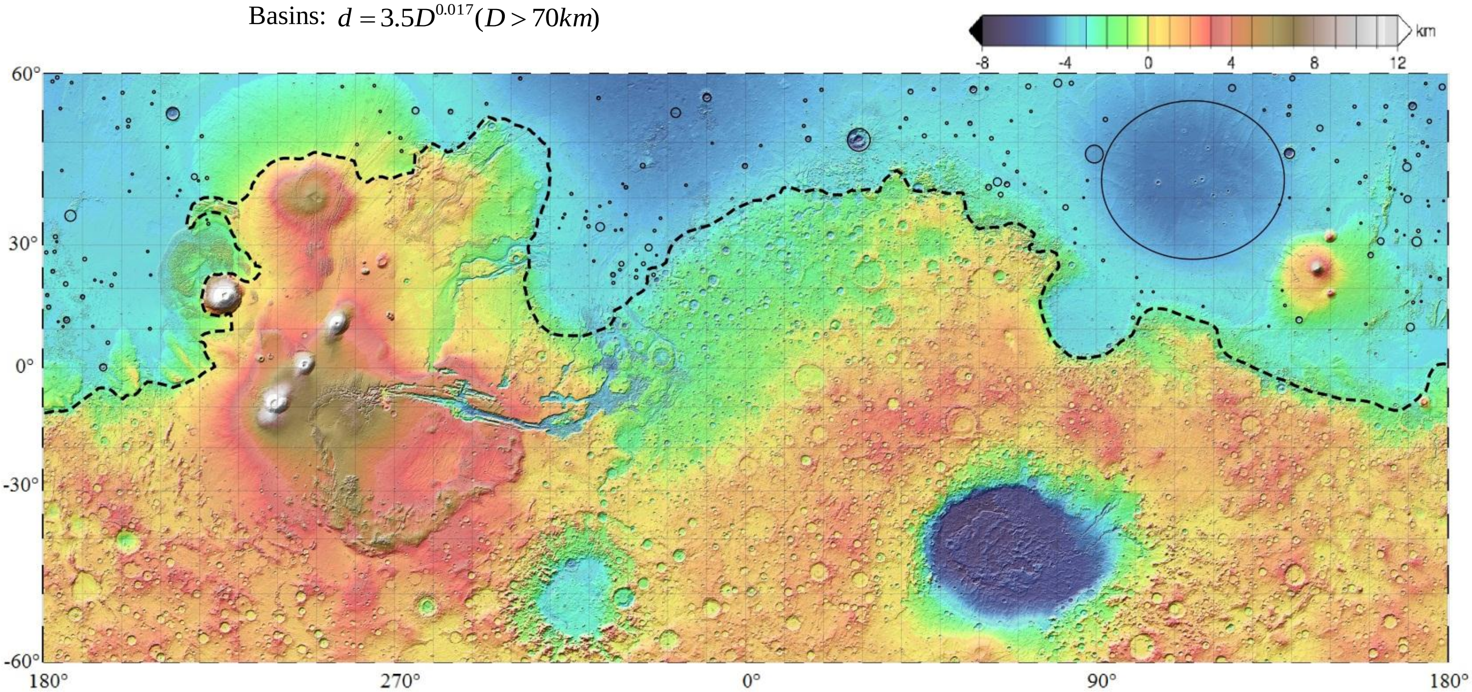


**Figure 1.** Map of the global topography of Mars from MOLA [3, 4, 5]. Craters included in study are circled in black. The dashed line represents the dichotomy boundary [13].

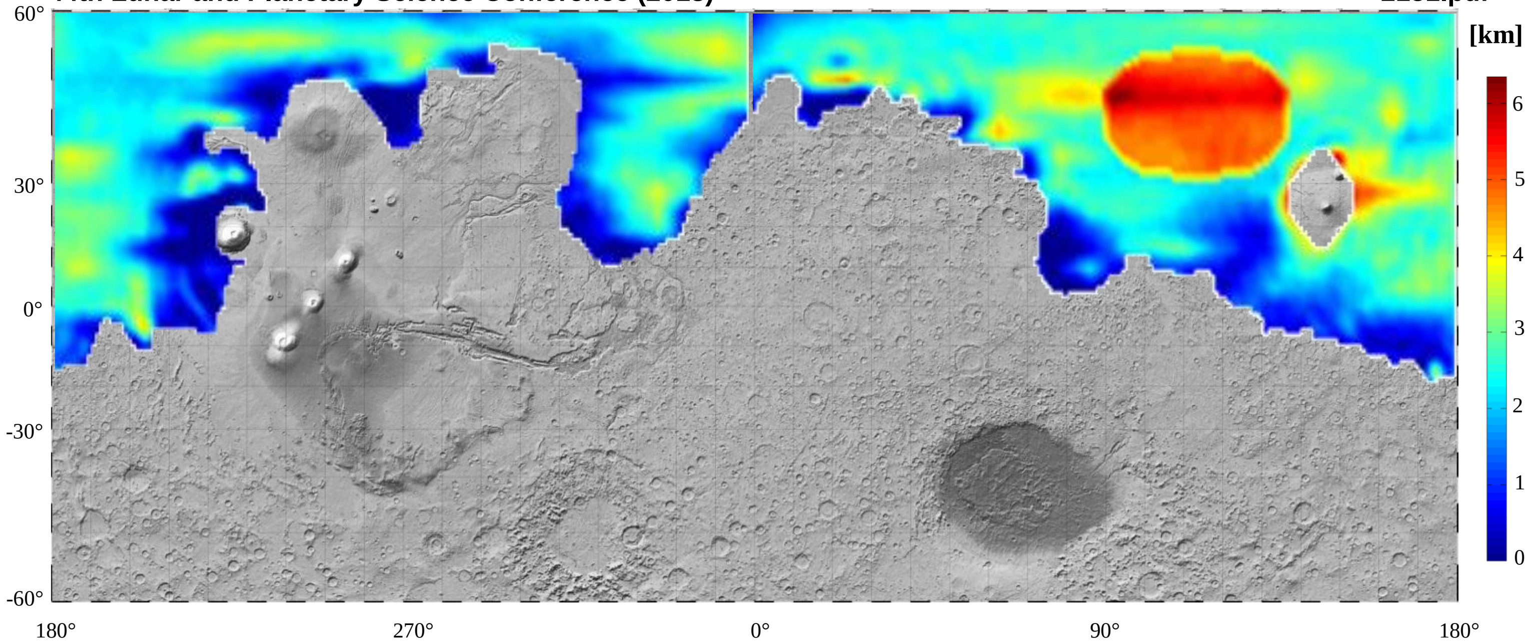


**Figure 2.** Fill thickness map in kilometers. Estimates are derived by interpolating a prefill surface from the fresh crater depths and subtracting this layer from the topography. Utopia Planitia fresh depths are estimated from the depth of Hellas Planitia, a basin of comparable size in the southern highlands. The Elysium volcanic rise and the polar region north of 60° latitude have been removed from the area of interest. The fill thickness values overlay the grayscale image of the topography data [3, 4, 5].

**Discussion:** The overall trend is that the average fill density is lower in the vicinity of the dichotomy boundary, which implies a greater contribution from sedimentation in these regions. This result is consistent with the observation of large outflow channels near Chryse Planitia and the heavily eroded region of Arabia Terra [10, 11, 12]. Areas further north, especially in the vicinity of the Tharsis volcanic rise, have a higher density more consistent with predominant contribution to resurfacing from volcanism.

**References:** [1] Andrews-Hanna J. C. et al. (2008) *Nature 453*, 1212-1215. [2] Zhong S. and Zuber M. T. (2001) *EPSL 189*, 75-84. [3] Smith D. E. et al. (1999) *Science 284*, 1495-1503. [4] Smith D. E. et al. (2001) *JGR 106*, 23689-23722. [5] Neumann G.A. et al. (2001) *JGR 106*, 23,753-23, 768. [6] Frey H. V. et al. (2002) *GRL 29*, 1384. [7] Konopliv A. S. et al. (2011) *Icarus 211*, 401-428. [8] Wieczorek M. A. and Phillips R. J. (1998) *JGR 103*, 1715-1724. [9] Garvin J. B. et al (2000) *Icarus 144*, 329-352. [10] Hynek B. M. (2004) *Nature 431*, 156-159. [11] Evans A. J. et al. (2010) *JGR 115*, 1-13. [12] Andrews-Hanna J. C. et al. (2010) *JGR 115*, E06002. [13] Parker T. J. et al. (1989) *Icarus 82*, 111-145.

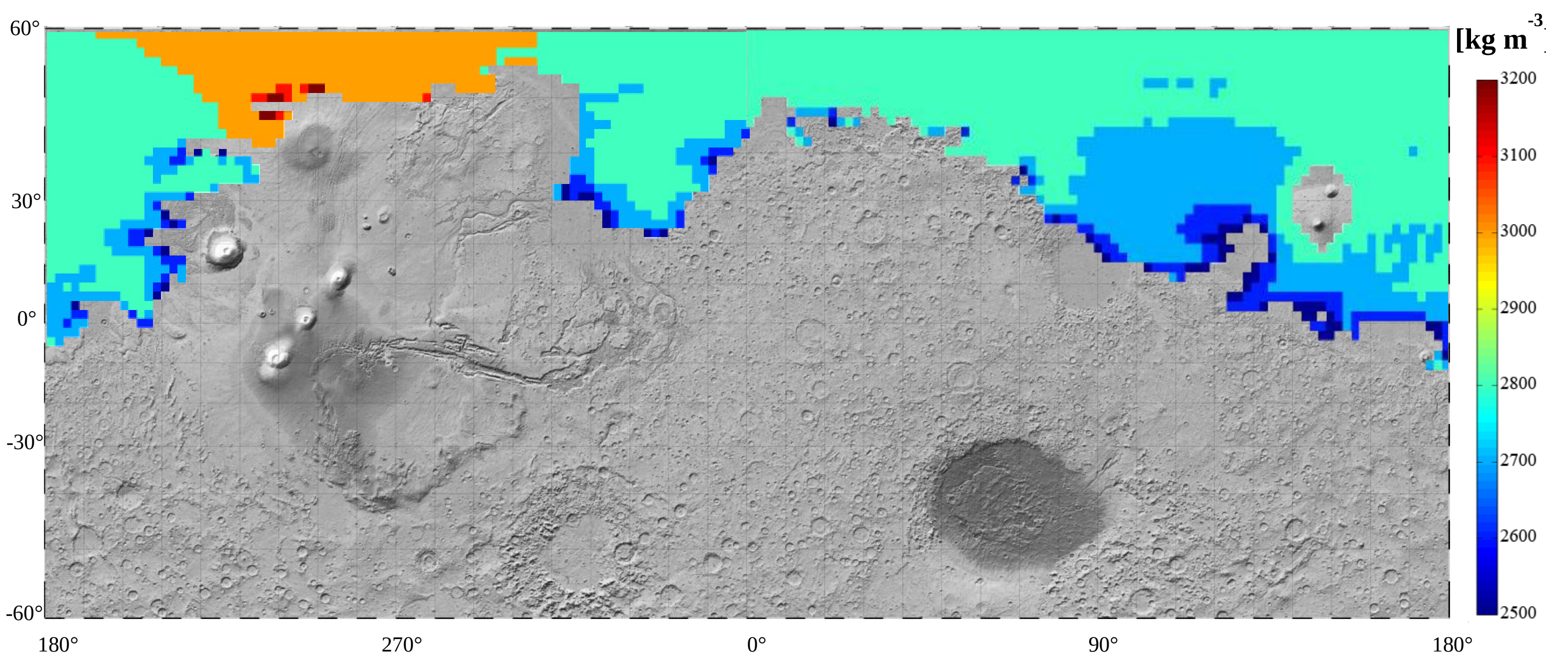


**Figure 3.** Average fill density map in kg m$^{-3}$. Measurements are taken at a spacing of 2 degrees in the latitudinal and longitudinal directions. The density results overlay the grayscale image of the topography data [3, 4, 5].