DEPTH/DIAMETER RATIOS OF 2.5+ KM CRATERS IN ARABIA TERRA, MARS, AND HINTS AT REFINING THE REGION'S HISTORY. S. J. Robbins[1,2], Haber, R.; and B. M. Hynek[2,3], [1]APS Department, UCB 391, University of Colorado, Boulder, CO 80309, [2]LASP, UCB 392, University of Colorado, Boulder, CO 80309, [3]Geological Sciences Department, UCB 392, University of Colorado, Boulder, CO 80309.

Introduction: Northwest Arabia Terra (AT) and Terra Meridiani comprise a broad region of middle ground between the Martian Southern Highlands (SH) and low-lying Northern Plains (NP). Their topography, crustal thickness, and crater population have shown them to have unique formation and modification histories from anywhere else on the planet and each other, but histories that have yet to be satisfactorily explained. A new database of 32,310 craters was created to study differenes in AT and the neighboring SH, and to directly test two different proposed histories: (1) AT represents a region of the SH that had up to ~1 km of crust removed by erosion [1], and (2) AT was a region of the ancient NP that was buried and subsequently exposed, showing the original Noachian-aged surface [2]. The crater size-frequency distributions, crater depth/Diameter ratios, and the thickness of Mars' crust suggest that neither scenario is easily reconcilable with the new datasets.

Hypotheses Tested: We tested Hynek & Phillips' hypothesis [1] that AT is a region of the SH that experienced massive erosion in the Late Noachian. We predict that this would manifest as a deficit of craters smaller than ~10-20 km in AT compared with SH, and most craters in AT would be significantly shallower because of erosion and redeposition. We also tested a Zuber *et al*. [2] proposal that AT is a region of original NP that was buried but subsequently exhumed, showing the original cratered basement material. This has no specific crater size-frequency prediction because the authors do not propose a timeframe for burial nor exposure, but it does suggest that craters in AT should be shallower than the neighboring SH.

Crater Catalog: Creating the new crater catalog was a two-step process where we first visually identified all >~2-km-diameter craters in THEMIS Daytime IR [3] mosaics (~230 m/px resolution) or Viking MDIM where THEMIS data were not available; we measured the diameter, center, and ellipse parameters of each crater. Second, we used MOLA 1/128°-gridded topography [4] to determine crater depth and verify diameter. The methods used to estimate these properties are discussed further in our companion abstract [5].

Size-Frequency Results: For this analysis, the THEMIS-derived diameters were employed in a non-cumulative size-frequency plot to study the differences between AT and the SH, shown as Fig. 2.

Prediction from Hynek & Phillips [1]. In this scenario of large-scale Late Noachian denudation in AT, one would expect craters at large sizes to exist with the same relative frequency in AT as the SH. Craters in the teen-diameters should be somewhat deficient in AT because those would be the maximum size eroded. The smallest craters we identified should have a steeper production slope due to accumulation subsequent to the denudation event. If the SH also incurred resurfacing, then its small crater population would also have a steeper slope at small crater diameters.

Prediction from Zuber et al. [2]. This proposal of burial "protection" of AT for a period of time is difficult to use to form a hypothesis for the size-frequency distribution of craters. If AT were buried soon after the Heavy Bombardment and exhumed ~1 Gy later, then it should have a reasonably similar crater population to a "pristine" SH distribution. But, if SH experienced massive erosion during that time, then AT should have more craters. If AT were instead buried during the Heavy Bombardment, then it should have less craters. Lacking specifics, we cannot make a reliable prediction.

Observations. Contrary to what we expect with the Hynek & Phillips hypothesis [1], we observe the opposite trend at smaller diameters. In general, AT's crater population does not show significant inflections in the size-frequency diagram for $2 < D < 128$ km. The SH's craters, however, shows a significant leveling off between 4.8-16 km, and craters smaller than that are in production. For craters $2 < D < 5$ km, AT's log-log slope on a cumulative size-frequency diagram is -1.15 and SH is -1.21. For craters 5-15 km, SH's slope is -0.33, and 15-40 km has a slope of -0.66. Craters 7-40 km in AT have a slope -0.85.

The slightly steeper slope for 2-5 km craters in SH may indicate slower erosion in the region, but the difference in slope is not statistically significant. The differences in slope for 40-128 km craters is also not statistically significant. However, the leveling of the slope in the SH for 5-15 km craters is significant; without consideration of other information, we may infer that it was the SH that experienced ~1-2 km of erosion while AT was protected, the opposite scenario as proposed in [1] with some elements from [2].

depth/Diameter Results: Fig. 3 shows the depths and diameters of 10,235 total craters in the sub-regions of AT (3285 craters) and SH (6950 craters) shown in Fig. 1. It shows two main features. First, there is a significant bimodal distribution of deep and shallow

SH craters; while this is also present in AT craters, it is significantly muted. Second, the deepest craters in the SH are ~50-100 m deeper than craters in AT (this is diameter-dependent), indicating possible enhanced deposition or a weaker crust in AT.

Test of Hynek & Phillips [1]. For this hypothesis, the craters in AT should be significantly more eroded than those in the SH due to the removal of crust and some local redeposition. This is not seen in the crater size-frequency distribution (Fig. 2). An alternative prediction hinges upon the timing of the erosive event: If the SH formed and were eroded (pursuant with research over the past 4 decades, c.f. [6]) in the Middle Noachian and *then* AT was resurfaced during the Late Noachian, the existence of the Late Heavy Bombardment of asteroids during the AT erosion event would produce a range of modification stages. This is what we see given the muted bimodality of shallow and deep craters in AT. However, one must still reconcile the additional craters in AT at $D < 10$ km.

Test of Zuber et al. [2]. The basic prediction from [2] is for craters in AT to be shallower than those in SH because they were covered (producing some erosion) and then exhumed, leaving remnant material that will also help create a shallower crater. While we cannot rule this out with our data, the expected heavy bimodal distribution of deep, fresh craters vs. shallow, eroded craters is not seen, and hence our data are inconsistent with this prediction from their hypothesis.

Area Trends. We also examined 5°×5° binned regions with the bin value as the average *d/D* within each bin for crater diameter ranges 1-4, 4-10, 10-20, 20-40, and 40+ km. None showed any statistically significant trend across the region (white outline, Fig. 1). This is contrary to predictions from both hypotheses, where one would expect craters in AT to be, in general, shallower than craters in the adjacent SH.

Crustal Thickness Results: We examined the thickness of the crust for three transects made orthogonal to AT (northwest to southeast, data from [2]). For [1], the thickness of AT should be similar to the SH near their boundary, show a minor thinning towards the NP, and then a sharp thinning at the boundary as seen elsewhere along the planet's North/South dichotomy. For [2], the thickness of AT should be similar to the NP and show a rapid thickening near the SH proper. The data show AT rapidly thickens to about 2× the NP crust. It then slowly increases in thickness by a factor of 2-3 through the adjacent mid-latitude region as it transitions to the thicker SH crust. These data are not easily reconcilable with either hypothesis.

Conclusions: Arabia Terra's formation and modification history still remain a mystery. Two very different mechanisms [1-2] were tested for consistency with new crater depth and diameter data as well as published crustal thickness maps, and the data examined together do not strongly support either hypothesis [1-2]. This complex region deserves further study due to its large planetary footprint and unique features that have yet to be satisfactorily explained.

References: [1] Hynek B.M. and Phillips R.J. (2001) *Geology*, *29*, 407-410. [2] Zuber M. et al. (2000) *Science, 287,* 1788-1793. [3] Christensen, P.R. et al. (2001) *JGR*, *106*, 23823-23871. [4] Smith D. E. et al. (2001) *JGR, 106,* 23689-23722. [5] Robbins, S.J. and Hynek, B.M. (2008) *11th MCC*, online only. [6] Craddock R. A. and Howard A. D. (2002) *JGR*, doi:10.1029/2001JE001505.

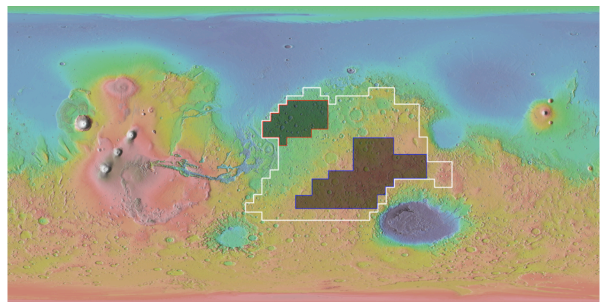

Figure 1: MOLA map of Mars [4] showing the broad region of interest (white border) and two smaller sub-regions of interest, isolating Arabia Terra (red border) and the adjacent Southern Highlands (blue border).

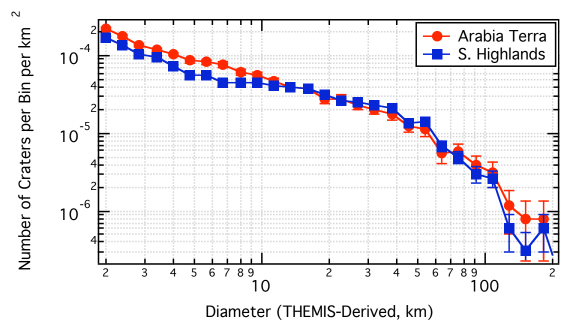

Figure 2: Non-cumulative crater plot of Arabia Terra and Southern Highlands craters, per the regions identified in Figure 1.

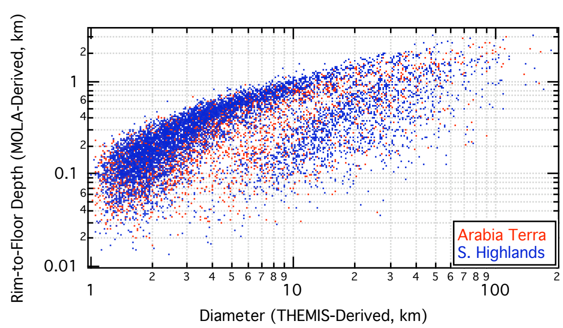

Figure 3: Crater depth vs. Diameter scatter plot for the sub-regions of interest in Fig. 1.