CRATER-BASED TESTS UNLOCK THE MYSTERY OF THE ORIGIN AND EVOLUTION OF ARABIA TERRA, MARS. K. K. Brugman[1], B. M. Hynek[2], S. J. Robbins[3] [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ (kara.brugman@asu.edu), [2]Laboratory for Atmospheric and Space Physics & Department of Geological Sciences, University of Colorado, Boulder, CO, [3]Southwest Research Institute, Boulder, CO.

Introduction: Mars exhibits a sharp dichotomy between its low-lying northern hemisphere plains and heavily cratered southern highlands. Across most of Mars the boundary is characterized by stark differences in elevation, crater density, and crustal thickness [1–2]. However, the Arabia Terra (AT) region straddles the dichotomy boundary and expresses characteristics of both the northern and southern terrains.

AT is located approximately 20ºW–60ºE, 0–50ºN, between Isidis and Chryse Planitiae. It contains tectonic features (most of which are associated with extension), modified erosional valleys, fretted terrain, and friable layers, all of which indicate a complex geologic history [e.g. 3–5]. AT's surface appears typical of, and was originally grouped with, the heavily cratered southern highlands, however data from *Mars Global Surveyor* showed that AT's crustal thickness is more consistent with the northern plains [6]. Subsequent hypotheses concerning AT's history focused on processes within the past ~4 Gyr that could have altered the region from northern or southern terrain. Our work uses the region's crater population to determine which of these hypotheses—if any—are most likely.

Hypotheses & Predictions: Five quantifiable crater characteristics were utilized in this work: cumulative size-frequency distribution (CSFD), crater depth-to-diameter (d/D) ratio, height from the crater rim to the surrounding surface (rim height), depth from the surrounding surface to the floor of the crater (floor depth), and the depth from the crater rim to the crater floor (rim-floor depth). Below are the main hypotheses for the history of AT, followed by our predictions as to how each might be reflected in the crater population.

1. AT is uplifted and exposed northern plains basement crust [6]. If AT represents a surface produced by removal of mantling deposits from the northern plains, then AT's surface crater population should match the buried northern plains crater population.

2. AT is a part of the southern highlands that was extensively eroded [7]. AT's CSFD should match that of the southern highlands, except AT's smaller craters should be deficient due to obliteration. The depth-to-diameter ratio (d/D) of complex craters 10 km in diameter is 1:8–9 [8]. If 1 km of material was removed from AT as proposed by [7], craters D ≤ ~10–15 km should be scarce relative to the southern highlands. AT's rim heights, floor depths and rim-floor depths should be depressed compared to the southern highlands, to reflect a history of heavy erosion.

3. AT is a standalone basin that formed when a giant impact crater was inundated by water from the putative northern plains ocean [9]. Due to an enrichment of crustal volatiles, AT should exhibit an abnormal abundance of layered ejecta crater morphologies and a high number of craters with central pits compared to the rest of the planet. Since this large impact could only have occurred > 3.8 Ga, AT should be much older than the southern highlands.

4. AT is the outer ring of a giant impact basin [10]. An impact would explain AT and the northern plains' thinner crust, and it would also reset the regions' geologic clocks. Thus AT's buried crater population should be similar to that of the northern plains, or at least older than that of the southern highlands.

Methods: Data for five crater populations were acquired: surface craters for AT and the southern highlands, and buried craters for AT, the southern highlands, and the northern plains.

For surface (visible) craters, this work used the morphometry determinations and crater database of Robbins and Hynek [11]. The morphometry data for a subset of the crater database (±44°N/S to ±90°E/W and 44-0°S by 90-180°W) were recalculated using a more accurate method [8]. Only craters with D ≥ 10 km were included; the finite resolution of MOLA data begins to significantly affect depth calculations when craters have D < 10 km [8].

In this crater database, ~ 98% of the craters are expressed in both MOLA topographic data and THEMIS daytime IR mosaics [11]. Because buried craters may not be seen in image data, this study used the Quasi-Circular Depression (QCD) database [12] to represent buried crater populations.

CSFDs were plotted for the five populations, then dated with the isochron fitting program, Craterstats2 [13] using the production function of [14] and chronology function of [15].

Results: Ages were fit to the five crater populations (Fig. 1), revealing that AT's surface is ~ 450 Myr younger than the southern highlands. The QCD population uncertainty is within the uncertainty of the southern highlands, so they can be considered to be approximately the same age (4.2 Gyr). Although the

QCD craters plot near each other, the AT QCD and northern plains QCD CSFD data are not identical; AT boasts more large QCDs per square km than the northern plains. Figure 1 indicates that the buried surface of AT is slightly older than the northern plains, implying that the two regions do not share the same ancient history.

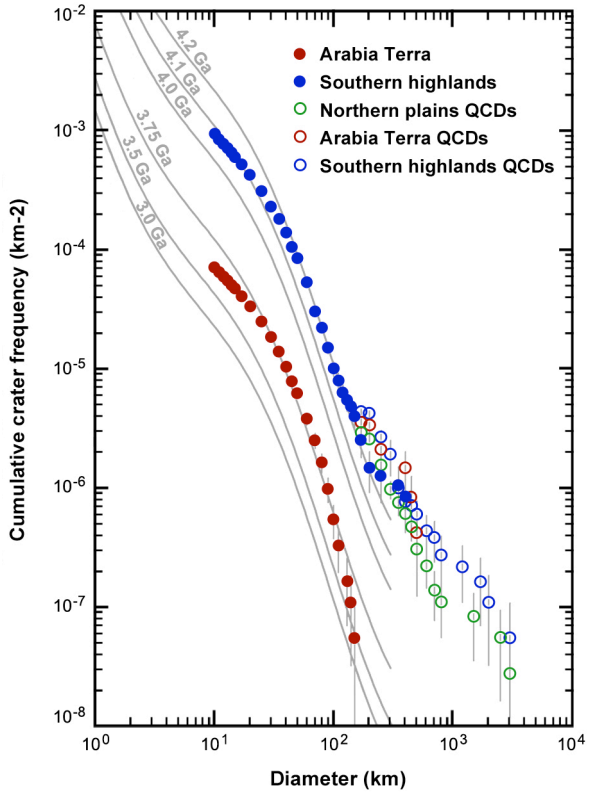

Figure 1: CSFD with isochrons for all crater populations and all regions. Surface craters = filled circles, QCDs = open circles.

Overall, the rim heights, surface-floor depths, and rim-floor depths of craters in AT and the southern highlands are strikingly similar (though AT rim heights are slightly lower). Recent crater data show that craters with central pits are no more abundant in AT than in many other parts of Mars, nor does AT have an unusual abundance of MLE craters [16].

Discussion: CSFDs indicate that Arabia Terra is younger than the buried northern plains and the southern highlands, which is the opposite of what was expected if Hypothesis 1 or 4 were correct. Hypothesis 3 asserts that AT has an abnormal abundance of layered ejecta crater morphologies based on *Viking*-era image data [9], but recent data do not support this assertion. Also, positing AT as a standalone basin is problematic in light of more recent valley network and river delta work, since these studies have found deltas where AT meets the northern plains (emptying northward) but not along the southern edge of AT [17]. One would expect the latter to be true if ancient rivers flowed across the southern highlands and emptied into an AT basin.

As for Hypothesis 2 [7], the data examined in this work show a clear link between AT and the southern highlands. AT's CSFD is nearly identical to that of the southern highlands except for a lower spatial density of craters (Fig. 1). However, our work did not fully substantiate Hypothesis 2 [7]. For the AT-as-denuded-southern-highlands hypothesis to hold with the condition given by [7]—removal of 1 km of material—AT's CSFD should flatten out at $D \leq \sim 10–15$ km. Instead, the slope of AT's CSFD appears consistent with the southern highlands' CSFD at $D \leq 25$ km (Fig. 1).

This, and the lack of discernable lowering of floor depths and rim-floor depths, could be explained if erosion of AT ended early enough for the crater population to be replenished by subsequent impacts. This explanation, and AT's young age, is consistent with Hypothesis 2's estimated timing of the erosional event(s) (3.9–3.7 Ga) and the age that work determined for AT (3.75 Ga) [7]. Hypothesis 2 also posited that eroded material was deposited in the northern plains, not in AT [7], which could explain why floor depths and rim-floor depths are not preferentially depressed compared to the southern highlands.

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