CRATER DENSITIES IN NOACHIS TERRA: EVIDENCE FOR OVERLAPPING EJECTA FROM ARGYRE AND HELLAS

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Summary: We compared crater densities in areas between Argyre and Hellas and to the east of Hellas to determine if ejecta from either basin affected CRAs in a measurable fashion and if ejecta from large impacts acted as a source of burial for basins recognized as not-visible "Quasi-Circular Depressions" (QCDs) [1,2]. Using MOLA data to identify buried basins, we find that the area that which likely received overlapping ejecta first from Hellas and then Argyre has the highest density of buried and total (visible plus buried) craters of the areas studied. This area also has one of the highest visible crater densities, indicating that it may have also received secondary impacts from the two large impacts..

Introduction: One of the most ancient parts of Mars, Noachis Terra is densely cratered and is primarily composed of Middle to Upper Noachian age surface units [3]. The majority of resurfacing in this area arises from impacts. The large impacts of Argyre and Hellas in the early Noachian had a significant contribution to resurfacing this area. Since not much reshaping would have occurred after these impacts due to the Noachian surface age, effects from these impacts can still be seen.

From differences in Crater Retention Ages (CRAs) derived from QCDs [2], it has already been established that the Hellas impact occurred before that of Argyre [4]. These CRAs were determined by using large diameter (> 200 km) QCDs superimposed on the two large impact basins. Though these CRAs provide general insight into the relative impact chronology between the large basins, the large diameter cutoff makes it difficult to see any effects from these two basins on the surrounding areas. One of the major issues for highland QCDs is what is burying the impact craters that cannot be seen in image data. Here we investigate whether ejecta from large Hellas and Argyre-size impacts may be a significant contributor to the burial of smaller impact craters in the Noachis region. Since the amount of ejecta is inversely related to distance from a basin's center, separable differences in the visible, buried, and total (visible + buried) crater densities both close to and between the basins could help determine whether ejecta is a burial source and a contributor of secondary cratering.

The effects of overlapping ejecta from two basins would be more pronounced than ejecta from only one basin, so we studied the area between Argyre and Hellas. We also studied the area to the east of Hellas to provide information on effects from a single large impact as a control on possible Argyre-Hellas combined effects. Results from the first study are reported here as well as preliminary results from the second study.

Study Areas and Cumulative Frequency Curves: We divided the area between Hellas and Argyre into three roughly equal sections (~2x10^6 km^2). With Argyre to the west and Hellas to the east, we designated these sections as the Western (2.20x10^6 km^2), Central (1.73x10^6 km^2), and Eastern (1.93x10^6 km^2) areas, as shown in Figure 1. For comparison purposes, we also considered the total area of all three sections. We also divided the area east of Hellas into four roughly equal areas distally located in Hellas diameter multiples away from the basin as shown in Figure 1.

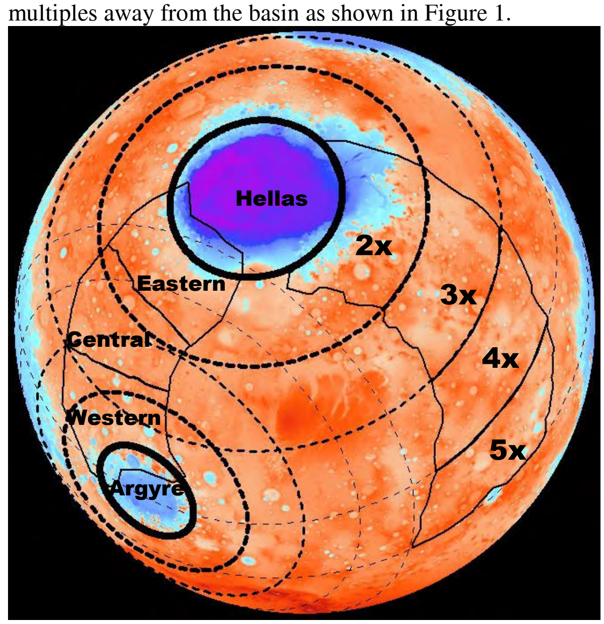

Figure 1. Study areas in relation to diameter multiples of Argyre and Hellas. Note that twice the diameter of Hellas and three times the diameter of Argyre rings overlap within the Central area. Of craters with a diameter>20 km, the Western area has 394, the Central area has 362, and the Eastern area has 348.

QCDs are revealed in MOLA gridded data through use of an IDL-based interactive graphics software package, GRIDVIEW [5] that reveals subtle differences in topography through stretching and other methods. For each of these areas, we have generated cumulative frequency curves for the visible, buried, and total populations from our counts of QCDs. Many of these curves have statistically separable curves at the small and mid-diameter ranges (25-90 km) that often follow a -2 power slope. Around 20 km, however, local depopulation is a factor. At diameters near 100 km, the small number of craters at this size within each area creates a source of error.

For this study, we mainly consider crater densities at the particular diameters of 25, 50, and 100 km. We use mostly N(50) densities to examine the visible, buried, and total populations across the areas. These densities along with N(25) and N(100) are shown in Table 1 for the three sections, the total area of the sections, and the areas to the east of Hellas.

Results: As seen in Table 1, the Central area has the largest density of QCDs of the areas studied. Its total crater density is also 20% larger than either the Eastern or Western area. The ratio between its visible and buried crater density is also the closest to 1:1. On the other hand, the visible crater density in the Eastern area is more than three times larger than its buried crater density. The Western area has the lowest visible crater density, which is almost half that of the Eastern area and consistent with Argyre being younger than Hellas.

TABLE 1. CUMULATIVE #/ MILLION SQ. KM

	W	C	E	Total	2x	3x	4x	5x
N(25)								
Visible	83	98	110	97	71	103	123	100
Buried	56	81	32	56	23	38	29	43
Total	139	177	142	152	94	141	152	143
N(50)								
Visible	18	31	35	27	19	21	27	26
Buried	15	27	11	17	6	7	6	11
Total	33	57	46	44	25	28	34	36
N(100)								
Visible	4	4	6	5	2	2	1	6
Buried	4	5	1	3	1	1	3	5
Total	8	9	6	8	3	4	4	10

In the areas east of Hellas, overall the visible crater densities increase as the distance from Hellas increases, indicating that craters pre-dating Hellas were buried more completely by Hellas' ejecta, that there was a greater density of secondary cratering closer to Hellas, or both. Total crater densities to the east of Hellas are less than those to the west, consistent with the fact that one ejecta blanket will have less of an effect on visible and buried populations than two overlapping ejecta blankets.

Discussion: From the low buried crater density in the Eastern area of N(50)=11, we believe that the Hellas impact obliterated pre-existing craters in that area, but secondary impacts increased the total crater populations in the Central and Western areas, as seen in the cartoon Figure 2 below.

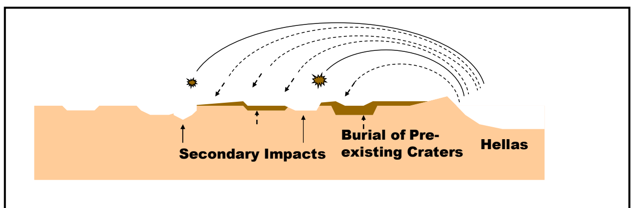

Figure 2. Noachis region following the impact of Hellas.

The Argyre impact obliterated craters in the Western area and buried craters in the Central area from the secondaries of Hellas and other impacts that occurred between the time of Hellas and Argyre as well as contributing its own secondaries to the Central area, as shown in Figure 3.

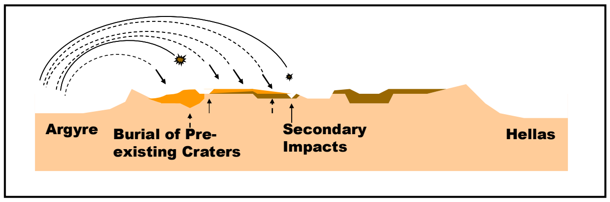

Figure 3. Noachis region following the impact of Argyre.

This would explain the larger total crater density of the central area (N(50)=57) as being due in part to secondaries from both large impacts. The central area also has the highest buried CRA at N(50)=27 because of the overlapping ejecta from the Hellas and Argyre impacts that covered many of the pre-existing craters. This is also seen when viewing the diameter multiple rings of Hellas and Argyre superimposed on the areas in stretched MOLA topography data (Figure 1). The location where diameter multiple rings from Hellas and Argyre overlap (the Central area) has the greatest crater density, which is consistent with secondaries from Argyre and Hellas contributing to the total in this area.

Since the Hellas impact occurred first, the visible crater population is the highest in the Eastern area (N(50)=35) and the buried population is the lowest (N(50)=11) since that area has not been much buried by ejecta as the other areas to the west. Of the three areas, the Western area underwent the most dramatic resurfacing the most recently, which explains its low visible CRA at N(50) of 18.

The ejecta blankets from both Argyre and Hellas have more of a prominent effect than ejecta from only Hellas, as seen in Table 1 where the areas west of Hellas have higher crater densities than to the east of Hellas. Without the ejecta from two basins contributing to both burial and secondary impacts, the buried crater densities to the east of Hellas remain almost constant until the 5x diameter multiple area because the ejecta from Hellas may have deeply buried the pre-existing craters in areas closer to Hellas to the point that they are undetectable even in topography data.

Conclusion: The differences in the crater densities of the three areas were separable enough to detect the existence of secondary cratering from the Hellas and Argyre impacts, especially in the Central area. We also were able to correlate ejecta from large impact basins as major sources of crater burial in Noachis Terra. We can see the more pronounced effect of ejecta from two basins compared to that from one basin.

References. [1] Frey, H. et al., GRL 26, 1657-1660, 1999. [2] Frey, H., JGR 111, 10.1029/2005JE002449, 2006. [3] Tanaka, K., JGR 91, E139-E158, 1986. [4] Frey, H., LPSC 35, abstract 1382. [5] Roark, J. et al., LPSC 31, abstract 2026.