

RELATIVE AGES OF THE HIGHLANDS, LOWLANDS, AND TRANSITION ZONE ALONG A PORTION OF THE MARS CRUSTAL DICHOTOMY FROM DENSITIES OF VISIBLE AND BURIED IMPACT CRATERS. G.E. DeSoto¹ and H.V. Frey², ¹Wright State University, Dayton, OH 45435, DeSoto.2@wright.edu, ²Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, Herbert.V.Frey@nasa.gov

Summary: Understanding the fundamental age relationships of the different parts of the Mars Crustal Dichotomy is essential to fully understanding the events that shaped the early history and formation of the surface of Mars. A dominant question is what are the true relative ages of the Northern Lowlands and the Southern Highlands? Using MOLA data from the Mars Global Surveyor and Viking visual images, a dataset of both buried and visible crater diameters was created over a nine million sq km study area of a section of the dichotomy boundary stretching from Arabia Terra to Utopia Planitia. Cumulative frequency plots on a log-log scale were used to determine the relative ages for the Highlands, the Lowlands, and the Transition Zone, separately for the visible, the buried and the combined total (visible+buried) populations. We find the overall Highland crater population in this area is slightly older than the Lowlands, consistent with previous global studies, but the Lowlands and Transition Zone are also very old and formed at roughly the same time. It appears that the formation of the Lowlands in this region formed contemporaneously with a large-scale resurfacing event in the Highlands, perhaps caused by the process responsible for the Lowland formation.

Introduction: The dichotomy is roughly a hemispherical difference both in age and topography separating the younger, smoother northern lowlands and the older more heavily cratered southern highlands. With controversial theories on its origin and fundamental structure [10, 11] it remains a mystery even today. The purpose of this study is to try to constrain an age of formation of a part of the dichotomy, and in particular, determine if there is a recognizable difference in the age of the Lowlands and Transition zone compared to the age of the Highlands.

Launched in November of 1996 the Mars Global Surveyor (MGS) carried with it an instrument designed to map the topography of Mars. This instrument, the Mars Orbital Laser Altimeter (MOLA) [12] revealed a large population of "Quasi-Circular Depressions" (QCDs), thought to be buried impact craters [5, 6]. The large number of QCDs, found on a global basis, imply that the bedrock of the lowlands is just as old if not a bit older than the exposed surface of the southern highlands [5, 6]. Buried basins in the Highlands suggest it too is older than previously thought. In this research we examine in more detail the age relations between the highlands and the lowlands in one area where the dichotomy is very well expressed. The intention was to map crater density across the Highland/Lowland boundary to identify the relative crater retention ages for the three distinct surfaces, the southern Highlands which were marked by a heavily cratered surface, the Transition Zone which is characterized by moderate cratering and knobby terrain, and the northern Lowlands which are very smooth, and nearly craterless. Using an interactive graphic program called GRIDVIEW, developed by Jim Roark of SSAI [7], QCDs >20km were found in 64 pixel/degree resolution MOLA topography grids and visible Viking images were used to determine which were visible.

Study Area: The study area covers more than nine million square kilometers, stretching over the regions of Arabia Terra, Syrtis Major, Ismenius Lacus, and Casius and into the Utopia Planitia. The Area can be view by Figure 1, which shows a grayscale, shaded relief image of the study are with each area labeled. The Highland zone in the study had 1,691 craters (649 visible, 1,042 buried) and covers an area of 5.95 million square kilometers. Most of the highland terrain was in the Arabia Terra Region, but also included some parts in the Ismenius Lacus and Syrtis Major Regions. The Transition zone had 424 craters (101 visible, 323 buried) and lies in the Ismenius Lacus Region, Syrtis Major Region, with parts in the Casius Region, and has an area of 1.80 million square kilometers. Lastly, 520 craters (59 visible, 461 buried) were discovered in the Lowland portion of the study area which mostly in the Casius Region and Utopia Planitia. The lowland area is 1.94 million square kilometers in size.

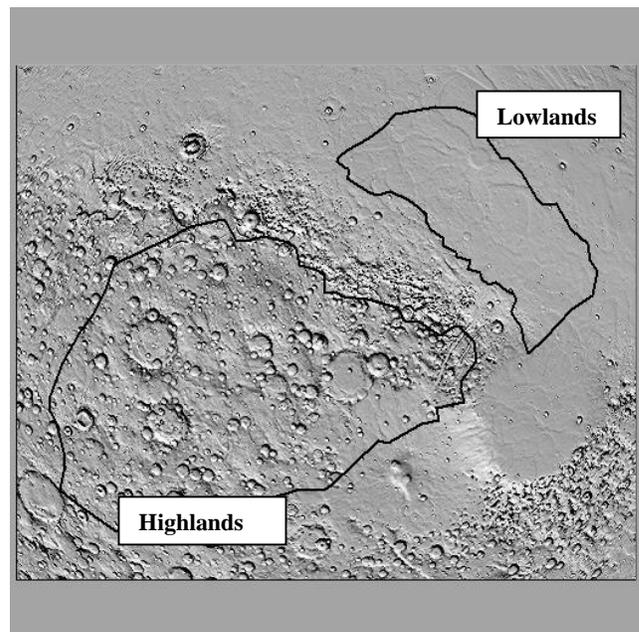


Figure 1. A grayscale, shaded relief image of the 9.7 M sq. Km. Study area, The Highland Zone is shown lower left and is heavily cratered, the Lowlands is the upper right, and are smooth plains. The Transition zone is the area in between.

Cummulative Frequency Curves: We separately plotted the visible, buried and total (visible+buried) populations. In this report we discuss mostly the buried populations, but start by showing the total population plot in Figure 2. Dashed lines in this and the following plot show -2 power law slopes for reference. Within the uncertainty of the data, the total population crater retention age for the lowlands and the transition zone are the same, and somewhat younger than the

total population crater retention age of the highlands. This is consistent with earlier results on a global basis [5,6]. In a companion paper we show that the crater retention age for the lowlands in this area is in fact identical to that of the global average age for the lowlands [12].

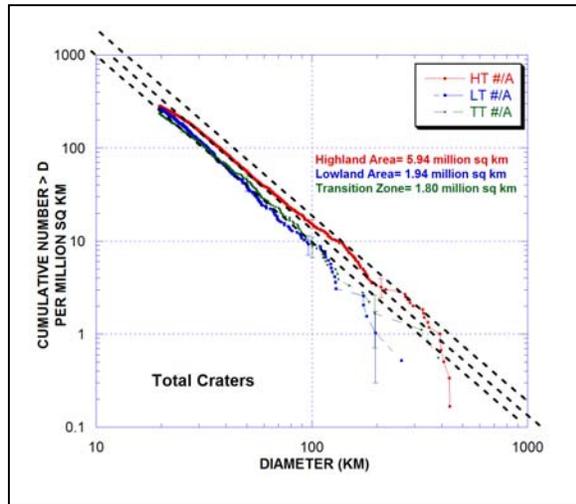


Figure 2. Cumulative frequency plot of the total crater populations of the Highlands, Lowlands, and Transition Zone in the study area.

Figure 3 shows a cumulative frequency plot for the buried populations in the highlands (red), lowlands (blue) and transition zone (green), and for reference the visible highland population (orange). Note that at large diameters the highland buried population follows a rough -2 power law slope down to about 100km, then falls off and resumes a -2 slope at about 80 km diameter. This depopulation may indicate a resurfacing of the highlands. The slope followed by the highland buried craters from 40 to 80 km is essentially the same as for the lowlands and transition zone over the range from 40 to 100 km. that is, the lowlands and transition zone have a crater retention age equal to that of the resurfaced highlands. Note that this age is noticeably older than that indicated by the visible highland population (orange), which itself is roughly Middle Noachian.

Discussion: These data are consistent with the results from global studies in that the lowlands are older than the visible highland surface. More interesting, it appears the transition zone in this area has the same crater retention age (CRA) as the lowlands. These both have a CRA younger than that given by the large diameter craters in the highlands, but apparently the same age as indicated by the middle diameter highland crater. The lowlands and transition zone appear to have formed at the time a major resurfacing event in the highlands came to an end, and the highlands in this area became a crater retention surface again. A likely cause for the origin of the lowlands in this area, which may have also caused the resurfacing in the adjacent highlands, is the formation of the Utopia basin by a giant impact [9].

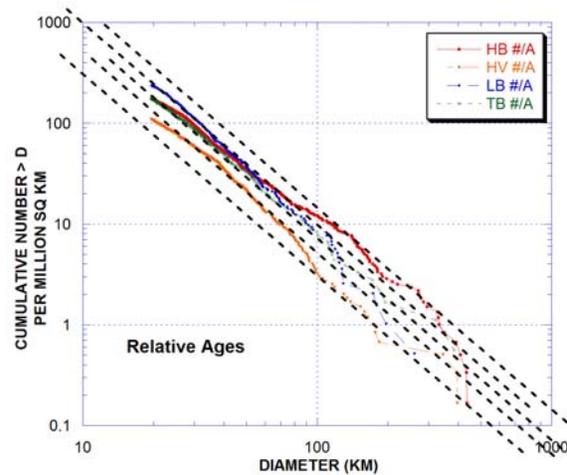


Figure 3. Cumulative frequency chart of the buried crater populations of the Highlands, Lowlands, and Transition Zone including the visible Highland surface to show their relative ages.

Conclusions: From investigations of the cumulative frequency plots for visible, buried, and total populations of craters in the three major dichotomy zones in this study area, some conclusions as to the relative ages of the Highlands, Lowlands, and Transition Zones can be made. The total crater retention age of the lowlands and transition zone are younger than the total crater retention age of the highlands, consistent with earlier global scale studies. The buried Highland surface is also older (at large diameters) than the buried Lowlands and buried Transition Zone surfaces, and that the Lowlands and Transition Zones buried surfaces are older than the visible Highland surface. But the the Lowlands and Transition Zone are the same age and formed at the same time in this region, and there appears to have been a major resurfacing of the Highlands also at the same time. A likely cause of this is the Utopia impact event [9].

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