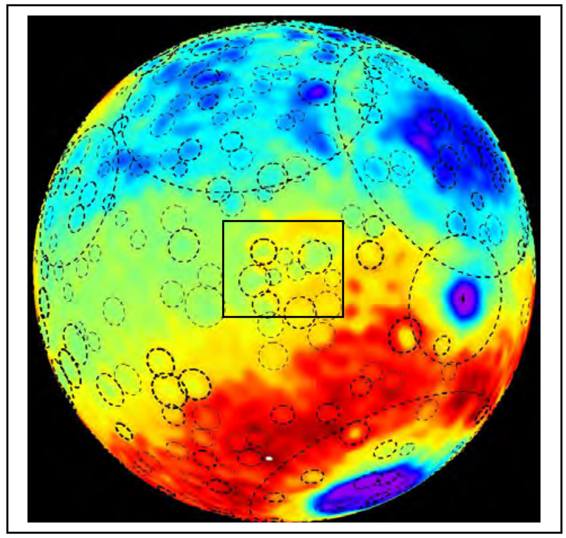
BURIED IMPACT BASIN DISTRIBUTION ON MARS: CONTRIBUTIONS FROM CRUSTAL THICKNESS DATA L. A. Edgar [1] and H. V. Frey [2], [1]Earth Sciences Department, Dartmouth College, Hanover, NH 03755, Lauren.A.Edgar@Dartmouth.edu. [2]Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, Herbert.V.Frey@nasa.gov.

Summary: Quasi-Circular Depressions (QCDs) indicate the presence of buried impact basins, but can not reveal basins buried so deeply that no topographic signature remains. We found a very large population of Circular Thin Areas (CTAs) in stretched versions of a crustal thickness data set that sometimes correspond to mapped QCDs but often do not. If the non-QCD CTAs are additional, more deeply buried impact basins, then (1) the buried population is much larger thanpreviously thought, especially in the lowlands and Tharsis regions of Mars, (2) crater retention ages previously estimated from QCDs alone are too low, (3) the lowlands and highlands may have the same N(300) crater retention age, substantially older than previously estimated, and (4) Tharsis is significantly younger than the oldest highland (and lowland) crust.

Introduction: Mars Orbiter Laser Altimeter (MOLA) data reveal a large number of "Quasi Circular Depressions" (QCDs) in both the highlands and lowlands of Mars, many of which are interpreted as buried impact basins [1,2]. Most of these roughly circular basins lack visible structure, but high precision topographic data have exposed their existence. QCDs have been used to relatively date the age of several different regions in the Martian lowlands as well as to compare the relative age of the lowlands and highlands of Mars [2]. However, ages based on QCDs only are likely minimum ages, since it is very likely there are many basins too deeply buried to have a signature in the topography alone. Another possibly useful data set includes crustal thickness anomalies from Neumann et al's [3] model derived from Mars Global Surveyor (MGS) gravity field and Mars Orbiter Laser Altimeter (MOLA) topography data. It assumes a uniform crust/mantle density contrast and a given mean crustal thickness. Additional corrections were made for density anomalies in the polar caps, major volcanoes, and the hydrostatic flattening of the core. Using an interactive software program called GRIDVIEW [4] to stretch the data, a large number of Circular Thin Areas (CTAs) – round features that represent thinner crust completely or partly surrounded by thicker crust – are revealed. Some examples are shown in Figure 1. Many of these do correspond to QCDs, but many do not. The non-QCD CTAs may be additional, more deeply buried, impact basins. If true, a better total crater retention age for the basement is obtained by combining QCDs with CTAs in the same regions. This combined data set can then be used to construct a more precise timescale for major events in Martian history and to improve our understanding of the evolution of Mars.



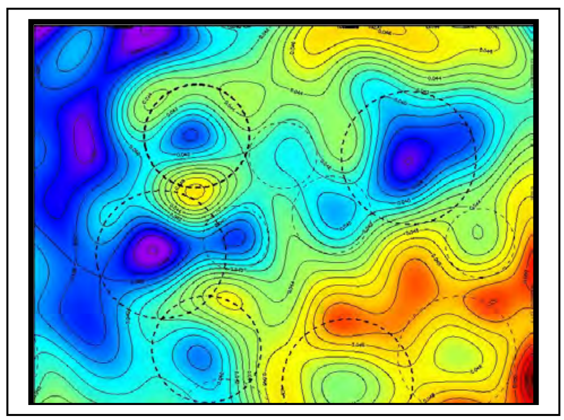


Figure 1. Top: Global Distribution of CTAs >300km. Red and orange colors reflect thicker crust, while blue indicates thinner crust [3]. Dotted rings represent likely CTAs. Large basins Chryse, Acidalia and Utopia are visible in the northern hemisphere, and Isidis and Hellas are visible on the right and lower right. Bottom: Colored and contoured crustal thickness data from boxed area (top). Contour interval 1 km. Colors have been stretched to reveal CTAs (dotted rings).

CTAs and QCDs: Many CTAs have a nearly coincident QCD. Presumably these represent the less deeply buried impact basins. There are many cases, however in which CTAs do not have a corresponding QCD; these are possibly older, more deeply buried, basins. If true, then (1) the buried population is larger than previously estimated, (2) crater retention ages that were previously determined for buried and total surfaces are too low, and (3) many areas (and maybe the lowlands as a whole) are older than originally thought based on QCDs alone [5].

We used GRIDVIEW [4], an interactive graphics software package, to stretch the crustal thickness data in the same way MOLA data were stretched to reveal the QCDs [2]. We searched for Circular Thin Areas larger than about 300 km diameter (a constraint imposed by the resolution of the gravity model used in the crustal thickness model), compared the CTAs found with the previously reported population of large diameter (> 200 km) QCDs, and produced cumulative frequency curves for QCDs, CTAs and a combined population of QCDs and non-QCD CTAs for three major areas of Mars: the highlands, lowlands and Tharsis. Figure 2 shows cumulative frequency curves for the combined data set in the highlands, lowlands and Tharsis, compared to cumulative frequency curves using only the QCDs. From these curves we derive N(300) crater retention ages for the three areas and compare those with N(300) ages based on QCDs alone (extrapolated from the N(200) ages reported by Frey [2]). These are shown in Table 1.

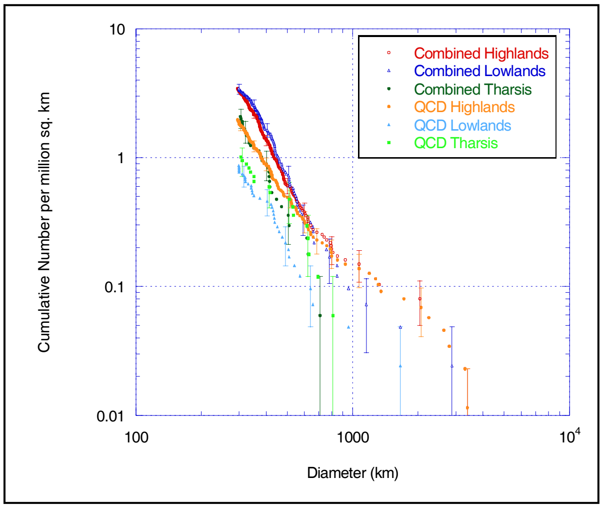


Figure 2. Cumulative frequency curves for highlands, lowlands and Tharsis for both the combined data set and the set of QCDs only. The combined data set reveals older ages for all regions, and a similar age for the highlands and lowlands (shown in red and dark blue).

Results: In the highlands there are more CTAs with corresponding QCDs, but in the lowlands there are more CTAs with no corresponding QCDs. The ratio of non-QCD CTAs to QCDs in the highlands is almost 1:1; in the lowlands the same ratio is 3.4:1 and in Tharsis it is nearly 2:1. In other words, in the lowlands and Tharsis there may be a greater proportion of basins buried so deeply they cannot be detected by topography alone. Presumably, this is because the lowlands and Tharsis contain great thicknesses of burying material. The presence of CTAs in the highlands and lowlands means both areas are likely older than previously thought, but the very much larger proportion of non-QCD CTAs in the lowlands means the lowlands may be very much older than estimated from QCDs alone. From Figure 2 it is clear that the combined QCD+CTA N(300) crater retention age for the highlands and lowlands is essentially the same, and that this CRA is significantly older than previously thought based on QCDs alone (Table 1). The Tharsis curve parallels that of the lowlands and highlands but is lower, so Tharsis is younger than the highlands and lowlands. Note also the population of large diameter basins for the highlands and lowlands. The lack of such basins in Tharsis (which are of a diameter that should most easily be preserved) may indicate that there is no ancient highland basement below Tharsis. This is discussed in a companion abstract [6].

Table 1. Crater retention ages (CRA) for the combined data set and QCDs alone, showing that the use of CTAs in addition to QCDs significantly raises the N(300) value.

	QCDs alone N(300)	QCDs & CTAs N(300)
Highlands	1.98	3.45
Lowlands	0.87	3.46
Tharsis	1.01	2.08

Conclusions: Based on a preliminary global survey of CTAs and comparison with QCDs > 300 km diameter on Mars, we suggest: (1) CTAs do represent a population of (often, more) deeply buried impact craters than is revealed by MOLA-derived QCDs alone, (2) ages previously determined for the highlands and lowlands based on QCDs are too low, (3) the combined data set, using non-QCD CTAs in addition to QCDs, is a better estimate of the true crater retention age of the (buried) surface of Mars, and that is older than previously thought, and (4) the N(300) crater retention ages derived from the combined QCD and CTA population are the same for the highlands and lowlands, but are significantly younger for Tharsis. Implications of this much larger population of buried basins for the early evolution of Mars and the origin of the lowlands and Tharsis are discussed in a companion abstract [6].

References: [1] Frey H. V. et al (2002), GRL, 29 (10), 1384, doi: 10.1029/2001GL13832. [2] Frey, H.V. (2006), JGR (Planets) 111, E08S91, doi:10.1029/2005JE002449. [3] Neumann, G. A. et al (2004), JGR (Planets), 109, E08002, doi : 10.1029/2004JE002262. [4] Roark, J. H. et al (2004), LPSC 35, Abstract #1833. [5] Frey H. V. and Fristad K. E. (2006), LPSC 37, Abstract #1391. [6] Frey and Edgar, LPSC 38 (this volume).