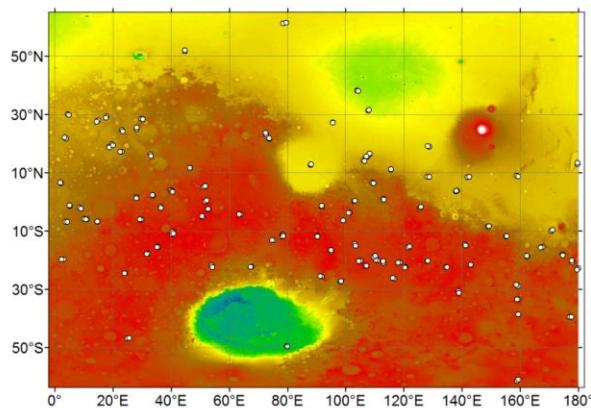


**A SEARCH FOR IMPACTOR EFFECTS ON MARTIAN CRATER MORPHOLOGIES AT THE SIMPLE-COMPLEX TRANSITION DIAMETER .** R. R. Herrick<sup>1</sup> and B. M. Hynek<sup>2</sup>, <sup>1</sup>Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320 ([rerrick@gi.alaska.edu](mailto:rerrick@gi.alaska.edu)); <sup>2</sup>Laboratory for Atmospheric and Space Physics, University of Colorado-Boulder, 3665 Discover Drive, Boulder, CO 80303 ([hynek@lasp.colorado.edu](mailto:hynek@lasp.colorado.edu)).

**Introduction:** Examining craters of identical diameter on a planetary surface is the closest one can come empirically to examining multi-km-scale craters formed from identical impact energies. If fresh craters of the same diameter are morphologically different, the two possible generic causes for the differences are target (e.g., rheology, layering, volatile content) or impactor (e.g., impact angle, velocity) properties. Based on a successful initial survey [1], we have been examining Martian craters within the simple-complex transition with  $7 < D < 9$  km. This diameter range represents roughly a factor of two variation in impact energy over which there is a wide variation in crater morphology [2]. In general terms, a strong correlation of crater morphology with geologic setting argues for target properties controlling variations in appearance, while the converse argues for impactor properties. In a companion abstract [3], we discuss the effects of target properties on craters in this size range.

Here we discuss an effort to isolate impactor effects on crater morphology. Our approach is to take the best-preserved 7-9 km craters from [2], starting with the eastern hemisphere of Mars, and examine pairs or clusters of craters that are proximally close to each other in order to hold both total impact energy and target properties constant. To this end we selected craters with preservation states 3 and 4 (minor degradation and pristine craters) in [2], longitude 0-180, and then sorted them according to the closest craters to them. For  $7 < D < 9$  km, there are 1541 craters with these preservation states, and we selected the 200 cra-



**Figure 1.** Locations of proximal pairs/clusters of craters 7-9 km in diameter in the eastern hemisphere of Mars. Maximum separation of craters in this data set (200 craters) is 38 km.

ters, or roughly 100 crater pairs (there are a few clusters of three and four craters), that are closest to other craters in this size range (Figure 1). In our data set the maximum center-center crater separation is 38 km. We studied this crater population in some detail to try to identify morphology differences that cannot be easily explained by variations in target conditions.

**Results:** We examined our survey population of craters using CTX, THEMIS Vis, and HRSC images, and gridded MOLA data. We removed from the survey the craters, and those paired with them, that had the following properties:

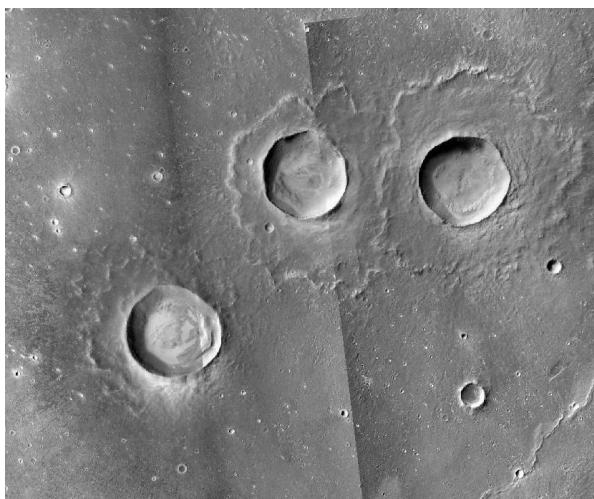
- Overlapping craters due to simultaneous impact (total of 10 craters);
- Pairs so close together that one crater is superposed on the other (4 craters);
- Craters clearly distorted by impact on highly uneven terrain (e.g., a larger crater's rim; 34 craters);
- Interior features of a crater clearly covered by post-crater fill or otherwise degraded (50 craters); and
- Crater is noncircular due to highly oblique impact (6 craters). We understand the effect of highly oblique impact angle on crater shape [e.g., 4,5] and are seeking to isolate other impactor properties in our survey.

After removing these craters, we were left with 96 close-proximity, well-preserved, non-overlapping, non-elliptical craters. With these remaining craters we examined in some detail the basic morphology and shape (particularly rim-floor depth) of the craters. As detailed in [1-3], craters in this size range usually have one of a few gross morphologies:

- Simple bowl shape;
- Flat floor with discrete slump blocks on the wall, sometimes with a central pit; and
- Mounding in the crater interior, occasionally as a well-developed central peak.

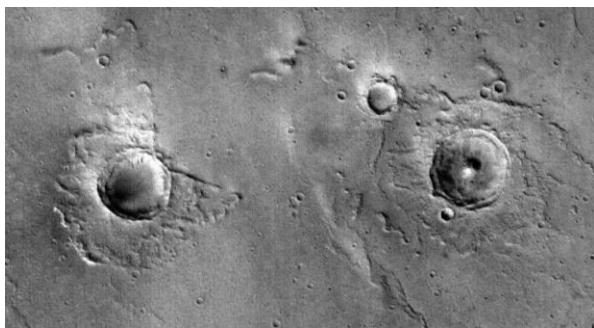
Some craters, particularly in the highlands, have both significant wall slumping and central mounding. Craters in the highlands also tend to have a less circular rim that probably reflects more subsurface heterogeneity in the target than in the northern plains.

Of the 96 craters that we examined more thoroughly, there were 71 craters in pairs, one trio, and one quartet, whose properties matched their partner craters closely in terms of morphology and depth (e.g., Figure 2). This left 25 craters (eleven pairs and one trio) that had a different appearance and/or different depths in



**Figure 2.** CTX images of a trio of craters centered at 3.9 N, 138.1 E. The three craters have identical depths, flat floors, and exhibit modest slumping of the rim walls.

the gridded MOLA data. Of these craters, in four cases further examination indicated that the difference in appearance between proximal craters is likely due to more dust cover “softening” features in the older crater of the pair, but otherwise the craters matched. In one case the difference in depth was due to no MOLA tracks running through one of the crater centers. In five cases it appears that subtle differences in the target (e.g., one of the craters on the ejecta blanket of a large crater, or straddling a tens of meters high topographic step) may be responsible for the differences in crater appearance.



**Figure 3.** HRSC image of pair of craters centered at 17.3 N, 22.6 E. Western crater does not have central peak, but does have uprange forbidden zone indicative of oblique impact. Craters have similar depths.

The two remaining pairs are particularly notable. In one pair (craters at 17.3 N, 22.6 E, Figure 3), one crater has a well developed central peak, while the other does not. The latter, while having a circular rim, has an uprange forbidden zone characteristic of a low-angle ( $\sim 15^\circ$  from horizontal) impact. In the other pair

(craters at 8.6 N, 128.4 E, Figure 4), the western crater has a much more irregular rim, with extensive rim slumping, and is  $\sim 350$  m shallower than the eastern crater, despite appearing to occur on an identical geologic setting.



**Figure 4.** HRSC image of pair of craters centered at 8.6 N, 128.4 E. Western crater has extensive wall slumping and is  $\sim 350$  m shallower than eastern crater.

**Discussion and Future Work:** In the vast majority of cases, the craters in the proximal pairs are nearly identical; differences are attributable to impact into differing targets and/or different post-impact modification. This study, in combination with others [1,3,6], makes the case that differences between craters of the same size can generally be attributed to differences in target properties, excepting highly oblique [4,5] and obvious clustered [e.g., 7,8] impacts. Our study suggests that variability in impactor velocity, shape, composition, and density, at least for the family of Martian impactors, has minimal effect on final crater morphology (other than the overall effect on crater size). The circular oblique/nonoblique flat-floor/central-peak pair (Figure 3) is notable, as it has not been documented that low-angle impact (but not low enough to form an elliptical crater) inhibits central peak formation, and we will look for additional examples of this. In future work we will expand our efforts on Mars and begin looking at lunar and Mercurian craters to evaluate initial results and look for additional exceptions to the rule.

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