#1661 – A Search for Impactor Effects on Martian Crater Morphologies at the Simple-Complex Transition Diameter

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Introduction

Examining craters of identical diameter on a planetary surface is the closest one can come empirically to examining 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. A strong correlation of crater morphology with geologic setting argues for target properties controlling variations in appearance, while the converse argues for impactor properties. To maximize variation in crater morphology, we have been examining Martian craters within the simple-complex transition with 7 < D < 9 km. **To specifically look for impactor effects, we examined the best-preserved craters in [1] sorted according to minimum distance to another crater of similar size**, which effectively means we are holding both impact energy and target properties constant. In a companion poster [Hynek and Herrick, #1046] we discuss the effects of target properties on craters.

The Observations

We selected craters with preservation states 3 and 4 (minor degradation and pristine) in [1], 7 < D < 9 km, and then sorted them according to the closest craters to them. Globally there are a total of 2796 craters with these diameters and preservation states. We selected those craters that had a maximum center-center separation of 38 km to another crater in this size range (329 total craters or ~160 pairs, with some trios and quartets; **Figure 1).**

Discarded Craters

We examined our these 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 **(Figure 2):**

•Overlapping craters due to simultaneous impact (total of 14 craters);
•Pairs so close together that one crater is superposed on the other (4 craters);
•Craters distorted by impact on highly uneven terrain (e.g., a larger crater's rim; 55 craters);
•Interior features covered by post-crater fill or otherwise degraded (91 craters); and
•Crater is noncircular due to highly oblique impact (15 craters). We understand the effect of highly oblique impact angle on crater shape and are seeking to isolate other impactor properties in this survey.

Survey Craters

After discarding the above craters, we were left with 150 close-proximity, well-preserved, non-overlapping, non-elliptical craters. 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.

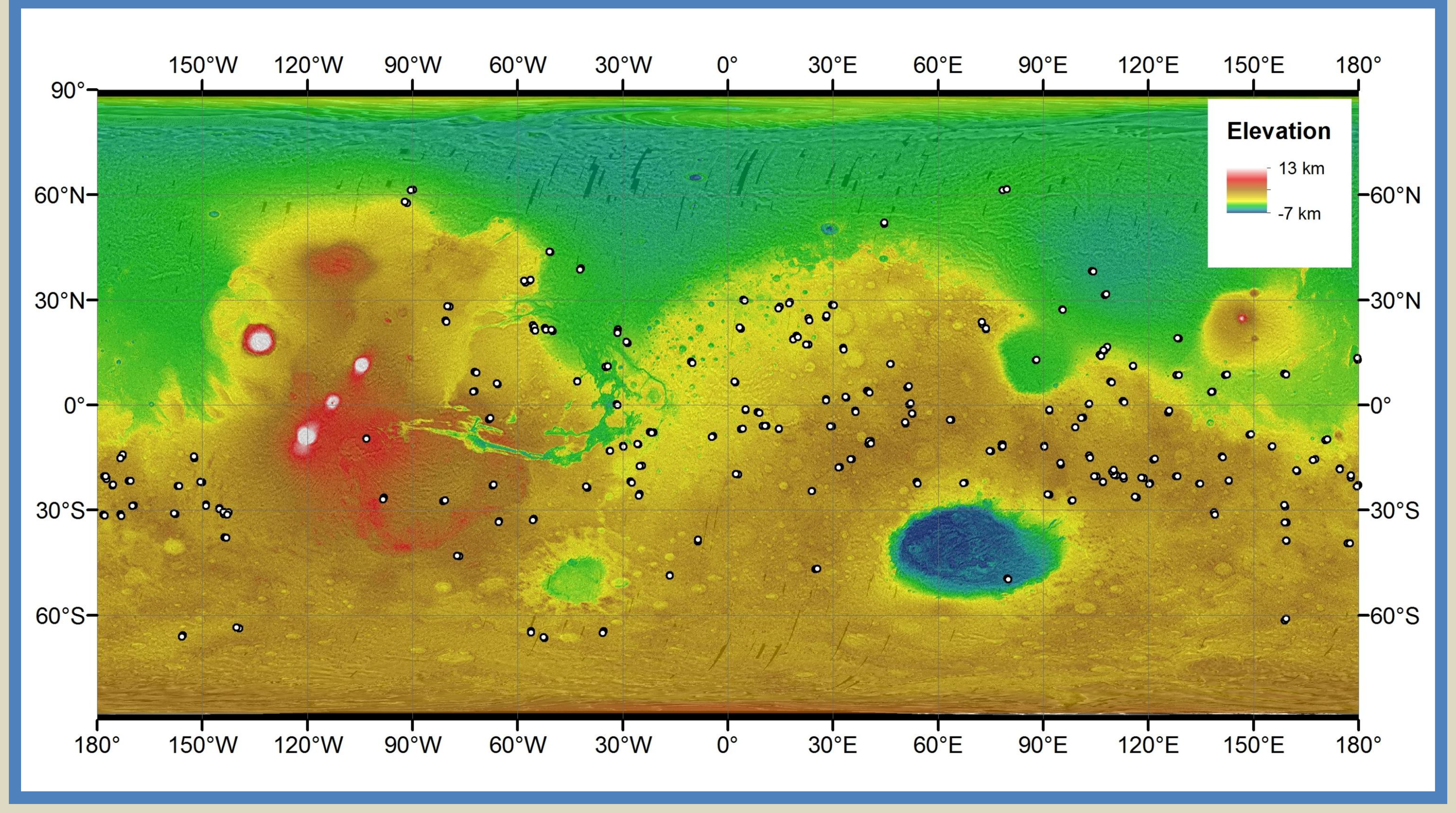
Some craters, particularly in the highlands, have both significant wall slumping and central mounding. Craters in the highlands also tend to have a less circular rim that probably reflects more subsurface heterogeneity in the target than in the northern plains. **Of these 150 craters, there were 117 craters in pairs, one trio, and one quartet, whose properties matched their partner craters in terms of morphology and depth (Figure 3).**

This left 33 craters (fifteen pairs and one trio) that had a different appearance and or different depths in the gridded MOLA data (Figure 4). Of these craters, in five 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 two cases the difference in depth was due to unfavorably located MOLA tracks . In seven 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.

The two remaining pairs are particularly notable. In one pair (17.3 N, 22.6 E, **Figure 5**), 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 (~15° from horizontal) impact. In the other pair (8.6 N, 128.4 E, **Figure 6**), the western crater has a much more irregular rim, with extensive rim slumping, and is ~350 m shallower than the eastern crater, despite appearing to occur on an identical geologic setting.

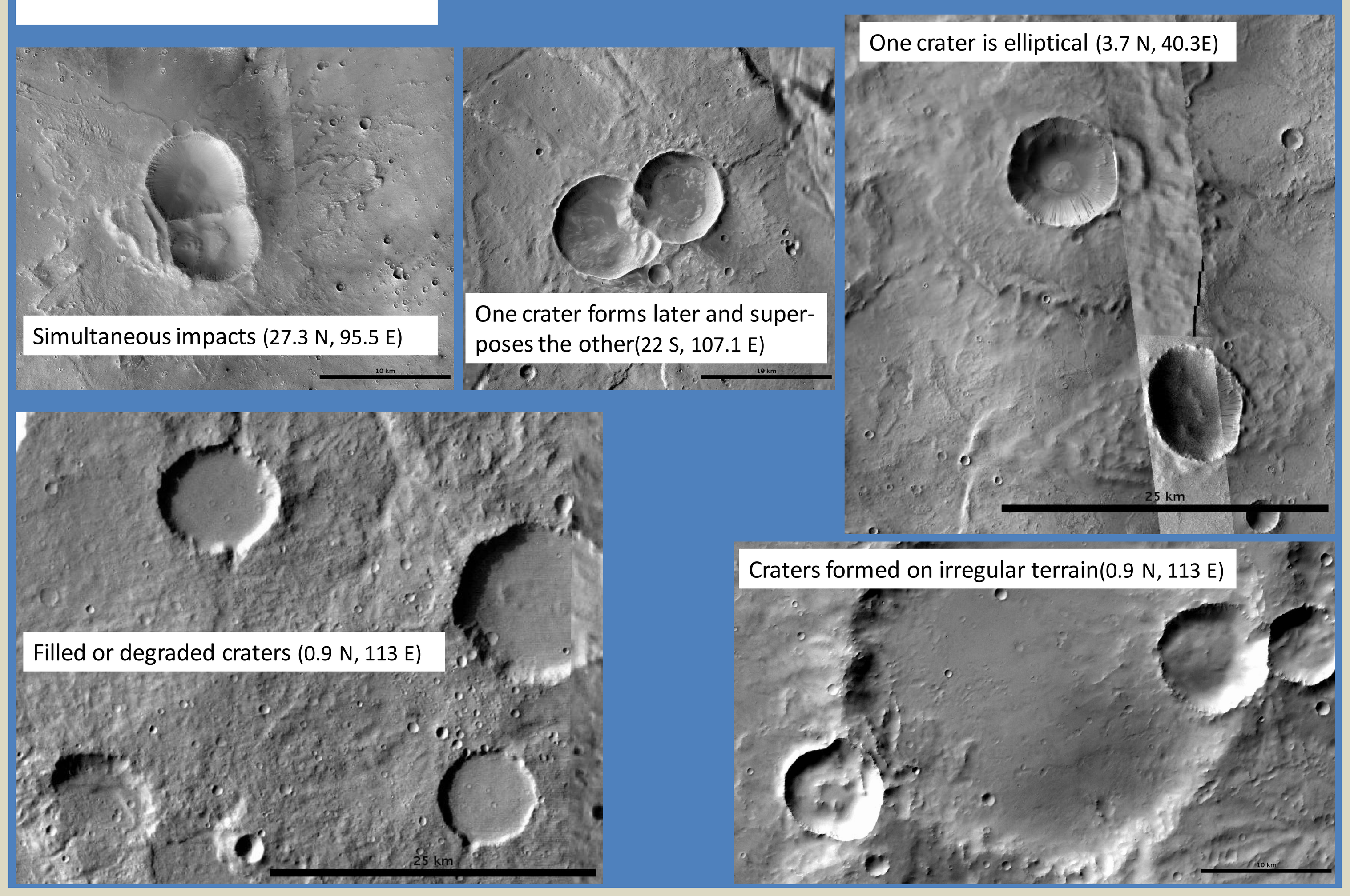
Crater Locations

Figure 1. Locations of well-preserved craters with 7 km < D < 9 km that are within 38 km of another crater in this size range (329 total).



Discarded Craters

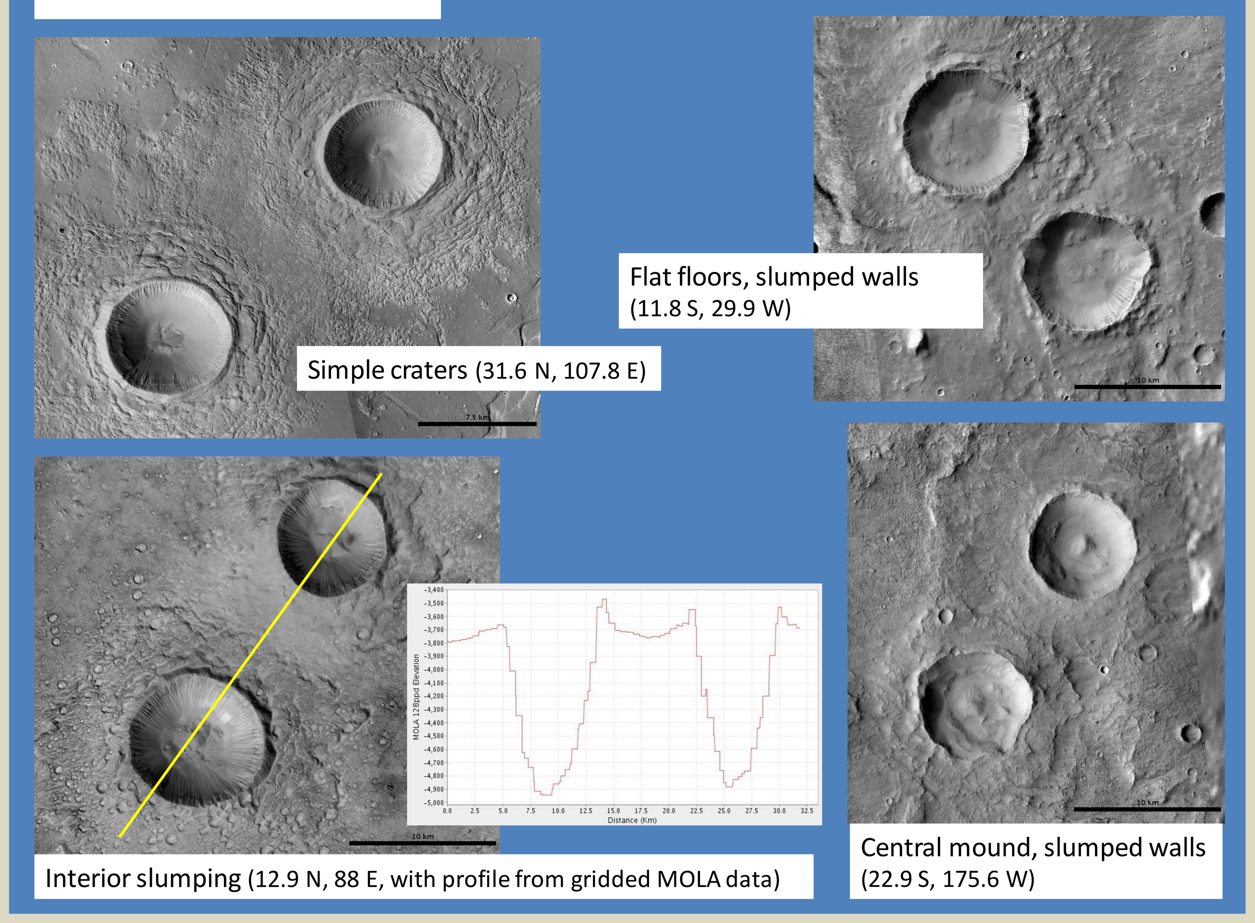
Figure 2. Examples of craters removed from the survey for various reasons (total 179 craters)



Simultaneous impacts (27.3 N, 95.5 E)
One crater forms later and superposes the other(22 S, 107.1 E)
One crater is elliptical (3.7 N, 40.3E)
Filled or degraded craters (0.9 N, 113 E)
Craters formed on irregular terrain(0.9 N, 113 E)

Matched Pairs

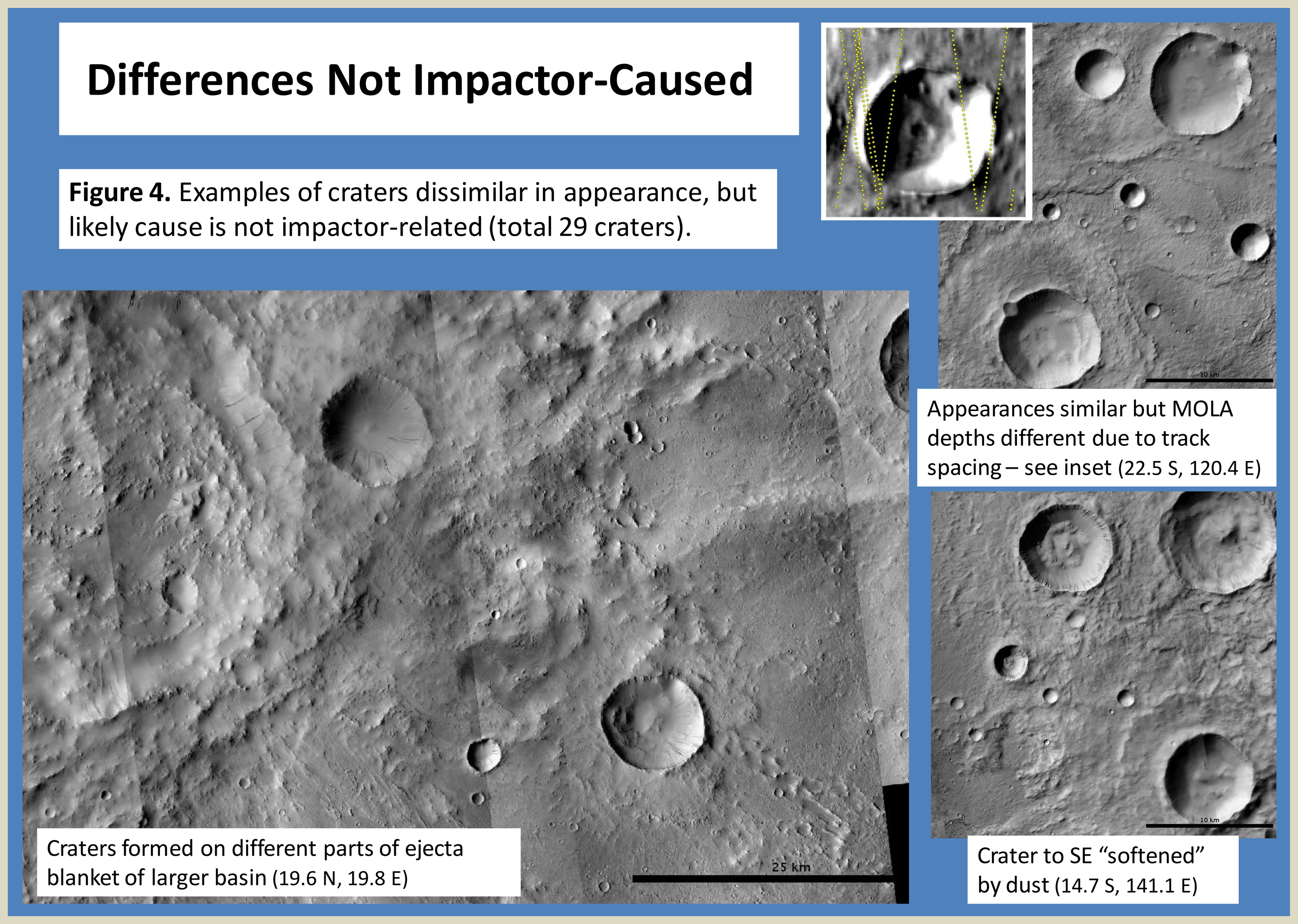
Figure 3. Examples of craters similar in both appearance and depth (117 total craters)



Simple craters (31.6 N, 107.8 E)
Flat floors, slumped walls (11.8 S, 29.9 W)
Interior slumping (12.9 N, 88 E, with profile from gridded MOLA data)
Central mound, slumped walls (22.9 S, 175.6 W)

Differences Not Impactor-Caused

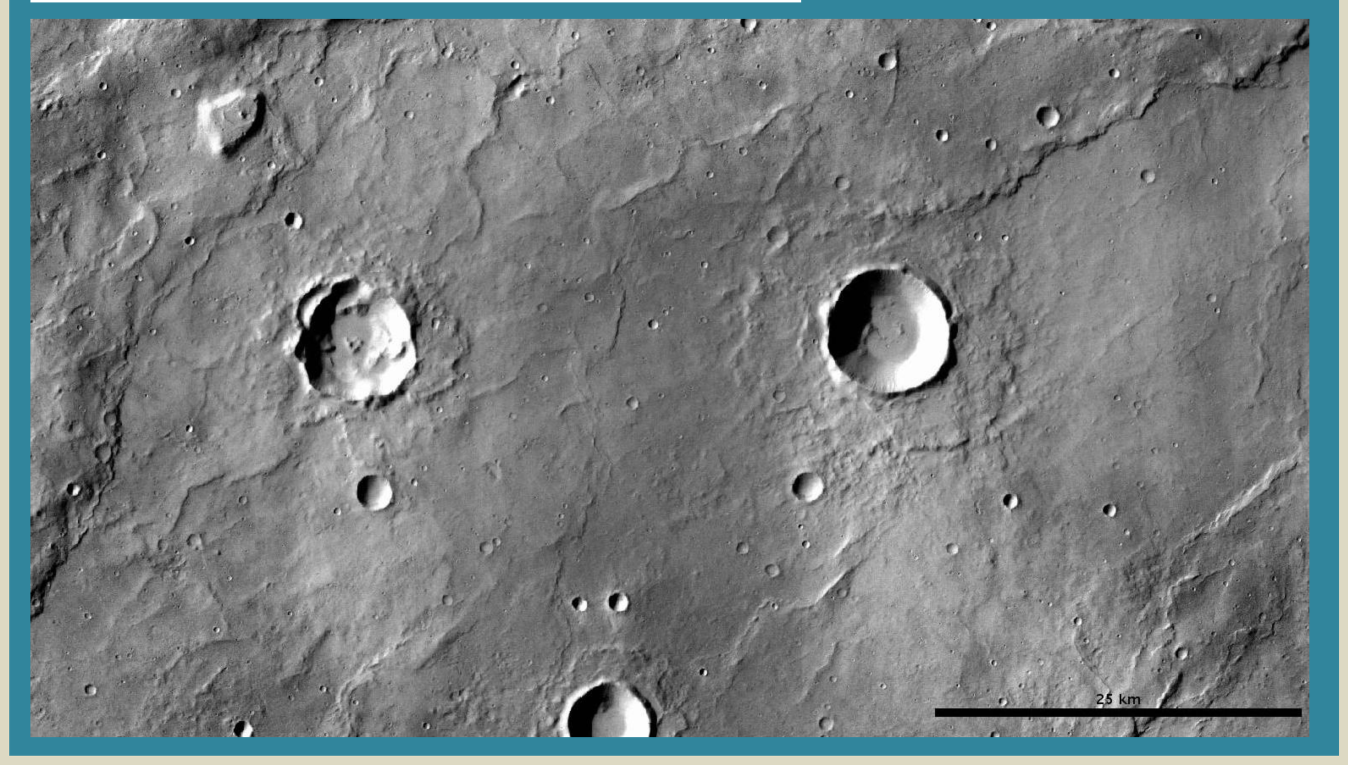
Figure 4. Examples of craters dissimilar in appearance, but likely cause is not impactor-related (total 29 craters).



Craters formed on different parts of ejecta blanket of larger basin (19.6 N, 19.8 E)
Appearances similar but MOLA depths different due to track spacing – see inset (22.5 S, 120.4 E)
Crater to SE "softened" by dust (14.7 S, 141.1 E)

Figure 5. West crater has uprange forbidden zone (17.3 N, 226 E)

Figure 6. Cause of differences unclear (8.6 N, 128.4E)



Discussion

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 [2,3,4], makes the case that differences between craters of the same size can generally be attributed to differences in target properties, excepting highly oblique [5,6] 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).

References: [1] Robbins S. J. and Hynek B. M. (2012) *JGRP, 117,* doi:10.1029/2011JE003966. [2] Herrick R. R. (2012) *LPSC 43*, #2380. [3] Herrick R. R. (2014) *LPSC 45*, #1782. [4] Hynek B. M. and Herrick R. R. (2015) *LPSC 46,* #1046 (this meeting). [5] Gault, D. E. and Wedekind J. A. (1978) *Proc. LPSC 9th*, 3843-3875. [6] Herrick R. R. and Hessen K. K. (2006) *MAPS, 41,* 1483-1495. [7] Schultz P. H. and Gault D. E. (1985) *JGR, 90,* 3701-3732. [8] Herrick R. R. and Phillips R. J. (1994) *Icarus, 112,* 253-281.