Examination of Differences of Similar-Sized Martian Craters at the Simple-Complex Transition as Revealed by High-Resolution Imaging and Stereo-Derived Topography. L. M. Dorn and R. R. Herrick, Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320 (ldorn@alaska.edu).

Introduction: Impact crater morphology varies in relation to both target and impactor properties. By studying the morphometry of craters within a narrow diameter range on a single planetary body, we can effectively hold impactor energy constant in an effort to better understand target influences on crater excavation and modification [1]. We chose a diameter range within the simple-to-complex transition to maximize the diversity of crater morphologies. We chose the target body Mars for its abundance of well-preserved, non-superposed craters in this diameter range, its varied geology, and its wealth of imaging and topographic data. Robbins and Hynek [2] examined global variability in the simple-to-complex transition diameter based upon several morphometric parameters measured from gridded MOLA data. Recent availability of high-resolution stereo imagery from the High Resolution Imaging Science Experiment (HiRISE) and the Context Camera (CTX) has made it possible to improve upon older topographic data from MOLA and HRSC through the generation and analysis of high-resolution digital elevation models (DEMs).

Data and Methods: Appropriate craters were chosen from the Robbins and Hynek global crater database [3] from all craters with diameters between 7 to 9 km and degradation state 4 (best preserved). These 581 craters were plotted on a recently updated geologic map of Mars [4] in ArcMap, where we looked for geologic units (Figure 1) with diverse surface characteristics bearing several potential craters. Hundreds of craters were inspected via CTX imagery in JMARS and narrowed down to several dozen that clearly showed the crater interior and most of its ejecta blanket in two images meeting the criteria for stereo photogrammetric analysis [5].

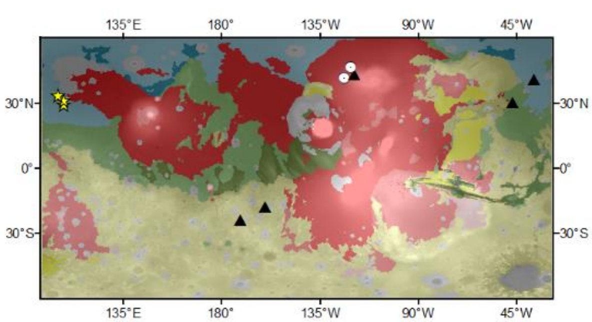

Figure 1. Map of Mars with geologic units and mapped craters/crater types. Red areas are volcanic units. Blue areas are lowlands units. Green areas are transition units. Yellow areas are highlands units. All other units are grey. Yellow stars = simple craters. Black triangles = complex central peak craters. White circles = complex central pit craters.

CTX data was pre-processed with ISIS. Preliminary DEMs of all craters were generated using the Ames Stereo Pipeline. DEMs and orthophotos of 10 craters (plotted in Figure 1) spanning 4 geologic units were successfully created using SOCET SET.

Crater DEMs and orthophotos were imported into ArcMap, where profiles were drawn through the crater centers (Figure 2) and several preliminary parameters were measured (Table 1).

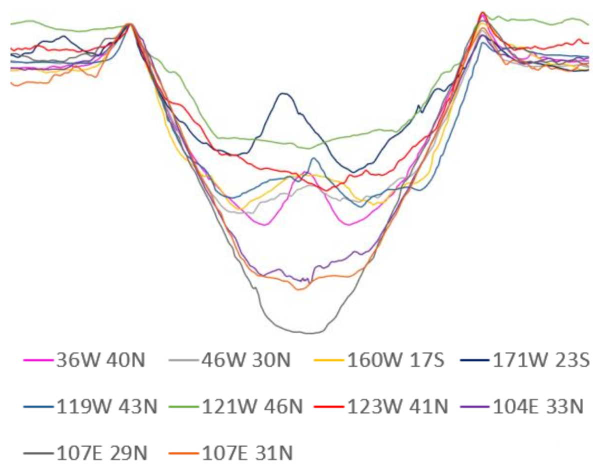

Figure 2. Scaled crater profiles.

Results: Three simple craters in Utopia Planitia, a lowlands area composed of thick sedimentary deposits over lava flows, have similar interior wall slopes and rim heights and are deeper than the complex craters. The simple crater located at 107.45 °E 29.59 °N has a d/D ratio exceeding 0.2 (Table 1) and can be classified as unusually deep. Slump deposits are evident in the profiles of the two shallower simple craters (Figure 2).

The three craters on the western flank of Alba Mons volcano exhibit greater morphological variation. Although all appear to be central pit craters from CTX images, CTX DEM-derived topography of the crater at 119.24 °W 43.04 °N reveals a central peak and possible summit pit. This peak structure was confirmed by the MOLA-HRSC merged DTM mosaic [6]. Other differences include a lack of terracing in the crater at 119.24 °W 43.04 °N (while present in those adjacent) and the crater at 121.03 °W 44.56 °N having a notably smaller average rim height relative to the surrounding surface.

Longitude (°E)	Latitude (°N)	Morphology (after [2])	D (km)	Rim-floor depth (m)	d/D
107.63	31.44	Simple	7.85	1499.6	0.19
107.45	29.59	Simple	7.65	1690.0	0.22
104.72	33.47	Simple	7.83	1529.3	0.20
-36.78	40.86	CpxCPk	8.64	1316.1	0.15
-46.69	30.33	CpxCPk	7.04	964.4	0.14
-119.24	43.04	CpxCPk	8.19	890.1	0.11
-121.03	46.56	CpxCPt	8.75	769.3	0.09
-123.99	41.60	CpxCPt	7.94	864.4	0.11
-160.05	-17.72	CpxCPk	6.95	842.7	0.12
-171.54	-23.76	CpxCPk	7.11	661.6	0.09

Table 1. Preliminary crater analysis results.

Two crater DEMs were produced in the northeast Terra Sirenum area on the same ancient highlands unit. Though both central peak craters possess similar rim heights, the crater at 171.54 °W 23.76 °S has a greater central peak height and shallow depth compared to the crater at 160.05 °W 17.72 °S (Gratteri).

Two crater DEMs were successfully processed in the Chryse Planitia area, on two different geologic units. Both central peak craters have very similar rim heights and interior slopes. However, the crater at 46.69 °W 30.33°N contains slump deposits on a flat floor and has a shorter, wider peak than the crater at 36.78°W 40.86°N, which has a taller, narrower peak and lacks a flat floor. The former occurs on a relatively shallow transitional sedimentary outflow unit while the latter is located on what is interpreted to be the same thick sedimentary lowlands unit [4] as the simple craters in Utopia Planitia.

The upper interior wall slope is nearly identical for every crater, with the exception of the low-rimmed crater at 121.03 °W 44.56 °N (Figure 2).

Discussion: Despite occurring within the same geologic unit, craters in Utopia Planitia and one in Chryse Planitia (although several more were observed using DEMs generated with the Ames Stereo Pipeline) exhibit differing morphologies (Figure 3). Boyce et al. [7] noted that southwest Utopia Planitia contains a high concentration of large simple craters with unusually deep cavities, which could be explained by a strong mafic rock layer exposed in nearby outcrops. Thicker cliff-forming units (Figure 3) in the uplifted rim are observed for the Utopia Planitia craters than those in Chryse Planitia (Figure 3); this may reflect that the near-surface materials are generally more homogenous and cohesive and thus more resistant to gravitational collapse. The presence of boulders observed along the inner wall and floor of several craters and the prevalence of unconsolidated slumps instead of discrete terraces is further evidence for weaker material in Chryse Planitia.

The previously unclassified [3] crater with a central peak structure at 119.24 °W 43.04 °N is unusual in that complex central peak craters do not typically occur near central pit craters or on volcanic terrain [1]. This could be an interesting case study in relation to the longstanding debate over the mechanics of central pit formation by volatile-driven explosion/collapse, collapse of a central peak, or impact into a weak target layer overlying a stronger material (discussed in [1] and [8]).

Future work will incorporate ejecta, rim, and cavity volume measurements with rim slope and interior crater structure observations to deepen our understand of the geophysical processes behind crater excavation and modification.

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References: [1] Herrick R.R. and Hynek B.M. (2017) *Meteoritics & Planet. Sci., 52,* 1722–1743. [2] Robbins S.J. and Hynek B.M. (2012) *JGRP, 117,* doi:10.1029/2011JE003967. [3] Robbins S.J. and Hynek B.M. (2012) *JGRP, 117,* doi:10.1029/2011JE003966. [4] Tanaka K.L. et al. (2014) *Planet. Space Science. 95.* 11–24. [5] Becker K.J. et al. (2015) *LPSC 46*, #2703. [6] Fergason R.L. et al. (2018) *USGS* http://bit.ly/HRSC_MOLA_Blend_v0. [7] Boyce J.M. et al. (2006) *GRL, 33,* doi:10.1029/2005GL024462. [8] Peel S. E. et al. (2019) *JGRP, 124,* 437-453.

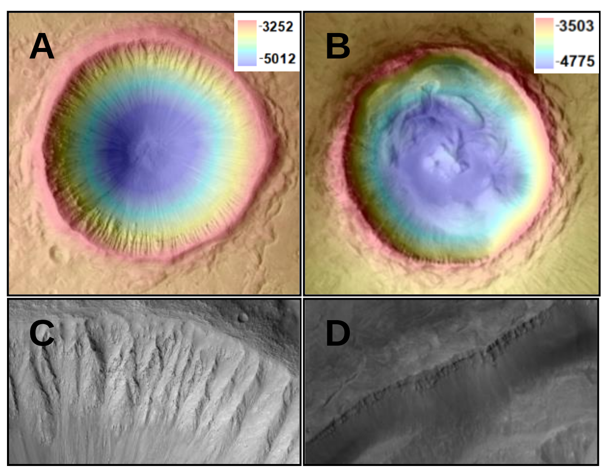

Figure 3. (A) SOCET SET DEM over orthorectified CTX image of simple crater (D=7.65 km) at 107.45 °E 29.59 °N. (B) Ames Stereo Pipeline DEM over orthorectified CTX image of complex central peak crater (D=8.65 km) at 42.04 °W 39.09 °N. (C) HiRISE image of thick cliff-forming unit of crater A. (D) HiRISE image of narrower cliff-forming unit of crater B. Images C and D have the same scale.