**MARTIAN CRATERS AT THE SIMPLE-COMPLEX TRANSITION DIAMETER.** R. R. Herrick, Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320 (rherrick@gi.alaska.edu)

**Introduction:** On Mars the transition from simple, parabolic craters to those having complex crater features (shallow and/or flat floors, central peaks, wall slumps) occurs over a factor of ~3 variation in diameter, from about 3 to 10 km, representing more than an order of magnitude variation in the kinetic energy of the impact [1,2]. This means that in some cases a bowl-shaped crater was produced on Mars by an impact with 10x the kinetic energy of an impact elsewhere that generated a crater with slumped walls and a central peak. In this work I seek to determine how craters formed from impacts of similar kinetic energies (i.e., craters of similar diameter) can have significantly different morphologies. To first order, these differences can be attributed to variations in target (e.g., composition, coherence, layering) or impactor (e.g., velocity, impact angle) properties. To assess the importance of various factors, and gain information regarding Martian near-surface crustal properties, I have initiated an investigation of the variation in morphology of impact craters on Mars in the 8-10 km diameter range.

**A Tale of Three Craters:** Consider the three craters in Figure 1. The crater in Figure 1A is bowl-shaped with a small, flat floor of loosely consolidated fill. It has a rim-floor depth of 1600 m and a rim height of ~200 m. The crater walls show a thick sequence of massive, coherent, poorly layering material outcropping in planform 1 km (~400 m depth) inward from the rim. The ejecta blanket has a thin outer rampart that extends 18 km from the rim, and an inner rampart with a maximum thickness of 75 m extending 7 km from the rim. The crater is located in the southern plains of Utopia Planitia, an area of giant polygons where achieving large polygonal spacing seems to require that a very thick layer behave coherently; the nature of the layer, volcanic versus sedimentary, has been a source of debate [3]. I examined 12 nearby craters in the 8-10 km diameter range with preserved ejecta blankets (yellow circles in Figure 2). Of those, four have filled interiors and presumably have been filled and then subsequently exhumed. Of the remaining eight craters, six are also bowl-shaped and quite deep. One has smooth walls and a small central mound, and one resembles the crater in Figure 1C.

The crater in Figure 1B is much shallower with a rim-floor depth of ~800 m and a rim height of ~100 m. The ejecta blanket has outer and inner ramparts, similar in nature to the crater in Figure 1A, that extend 12 and 6 km from the rim, respectively. The crater walls are smooth, sloping down to a prominent central mound. Downward from the rim, a coherent layer outcrops that varies in thickness from a few hundred to a few tens of meters in planform, and wall slumping is enhanced where this layer is thinnest. No obvious outcrops of layered or coherent rock are visible in the central peak or slump mounds. This crater is located in NW Chryse Planitia where the outflow channels of Kasei Valles likely deposited sedimentary loads. The seven nearby craters of a similar size (white circles in Figure 2) have similar morphologies and depths, although there is some variability in the size of the central mound or the nature of the slump blocks.

The crater in Figure 1C has a rim-floor depth of 850 m. The floor of the crater is remarkably flat, with a shallow central pit partially surrounded by a low ring of outcropping mound material. The wall slumping surrounding the floor occurs as more discrete units than the slump mounds in Figure 1B; not quite full terraces, but close. No unusual floor textures, pooled material, or onlapping relationships are evident that would indicate that the flat floor represents a melt sheet. There is an inner rampart 60 m high that extends 7 km from the rim, and a nearly buried outer rampart that extends to 11 km. The crater occurs on the volcanic plateau associated with Elysium Mons. The area has wrinkle ridges, and the flow margins of individual volcanic flows are regionally abundant. Of nine craters in a similar geologic setting on the Elysium plateau (pink circles in Figure 2), eight have a similar morphology to Figure 1C, with small variations on the nature of the floor deposits. The lone exception has a prominent central mound and is more similar to Figure 1B.

**Discussion and Future Work:** Because the three craters occur in distinctly different geologic settings, and similar-sized craters within each geologic setting largely have a similar appearance, I conclude that target properties are the dominant cause for the differences between the craters. The extent and nature of the ejecta blankets are similar enough that I consider subsurface volatile content unlikely to be a major factor in interior differences. I concur with the interpretation of others [e.g., 4] that the crater in Figure 1A, in Utopia Planitia, is in a region where at least the upper two kilometers is homogeneous and atypically strong (perhaps massive mudstone?). I interpret the shallower depth, central mound and slumping in Figure 1B to be due to the complex crater formation processes of floor uplift and wall collapse in what I interpret to be a heterogeneous, weaker, less consolidated target material in NW Chryse Planitia, as might be expected for what is likely a thick sequence of outflow deposits in the region. I interpret the flat floor and discrete slump
blocks of Figure 1C to be due to excavation in a layered target, perhaps layered basalt flows interspersed with weak tephra layers. In this case the flat floor represents a hard layer, just underneath a weak layer, at the base of a nonparabolic transient cavity, with the central pit representing some minimal penetration into the hard layer (the "sombrero" model for excavation in a layered target). Discrete slump blocks occur due to preferential inward sliding along weak layers.

For Mars, a variety of analyses have examined regional variations in morphometric measurements (e.g., depth/diameter) and the onset diameters for different morphological features in an effort to understand regional variations in crustal properties [e.g., 2,5]. The conclusions here are broadly consistent with those works, and I think the approach here provides some unique insights into both cratering mechanics and regional crustal variations. Figure 2 shows all of the 8-10 km diameter craters on Mars with preserved ejecta blankets. I will continue to expand the analyses to different areas, and I will assess to what extent anomalies within a regional cluster can be attributed to target properties. The initial analysis of highland craters with \( D = 8-10 \) km shows more extensive wall slumping and central mound formation than plains craters, perhaps resulting from formation in a very poorly consolidated megaregolith. It may also be useful to examine similar-sized craters in a lower-diameter part of the simple-complex transition range, such as 4-5 km craters.


Figure 1. Three craters of similar size with dramatically different interior structure. Crater A (CTX image; 29.7 N, 116.5 E) is essentially a simple crater with slight floor filling. Crater B (CTX image; 33.3 N, 315.9 E) has a prominent central mound. Crater B (THEMIS Vis image; 19.2 N, 161.6 E) has a flat floor, a hint of a central pit, and terraced walls. Scale bar is 5 km, and craters are ~9 km in diameter.

Figure 2. Martian impact craters with \( D = 8-10 \) km with preserved ejecta. Labels A, B, and C correspond to craters in Figure 1. Yellow, white, and pink circles indicate nearby craters in a similar geologic setting to A, B, and C, respectively.