IMPACTS INTO ICE-RICH DEPOSITS ON MARS: EXCESS EJECTA CRATERS, PERCHED CRATERS, AND PEDESTAL CRATERS. S. J. Kadish[1] and J. W. Head[1], [1]Brown University, 324 Brook St, Box 1846, Providence, RI, 02912 (Seth_Kadish@Brown.edu).

Introduction: Classification of crater/ejecta morphologies [1] in the mid latitudes on Mars have led to the identification of three crater types that indicate impacts into an ice-rich surface layer. These morphologies include excess ejecta craters (EE) [2], perched craters (Pr) [e.g. 3-5], and pedestal craters (Pd) [e.g. 1,6-8]. Each of these morphologies has either ejecta or a pedestal that has a volume greater than its crater bowl. Consequently, a formation mechanism has been proposed for each that involves armoring or ejecta covering of an ice-rich substrate. This protective covering preserves the ice, which eventually sublimates from the intercrater terrain, most likely due to climate change from obliquity variations [e.g. 9,10]. This lowers the elevation of the surrounding terrain, yielding craters that are either topographically perched or that have excessively voluminous ejecta.

The similarities between these morphologies and their proposed formation mechanisms suggest a potential genetic relationship. Here, we discuss evidence for this relationship based on topography, morphology, and geographic distribution, and identify the key differences in the formation processes that likely yield the three distinct crater types.

Excess Ejecta Craters: As defined by *Black and Stewart* (2008), EE are fresh craters, ranging from ~5 to 18 km in diameter, that have ejecta volumes above the pre-impact surface that are at least 2.5 times the volume of the crater cavity (Figs. 1,2). This volume corresponds to an excess ejecta thickness of 20 to 100 m [2]. The crater bowls, which may contain central pits, reach 600 to 1400 m depth below the elevation of the surrounding surface. They tend to have double-layer ejecta (DLE) (Fig. 1), although examples with single-layer ejecta (SLE) exist (Fig. 2). The initial survey for EE identified the highest concentrations in Utopia Planitia [2].

Perched Craters: Ranging from ~6 to 23 km in diameter, Pr include all craters whose floors are at or above the elevation of the surrounding terrain [3-5] (Fig. 3). These have necessarily undergone significant infilling to raise the depth of the crater cavity, resulting in nearly constant depths regardless of the crater diameters [4,5]. The ejecta of Pr often shows evidence of degradation or erosion, and may be SLE or DLE. Surveys indicate that Pr are located primarily in the northern lowlands including Utopia and Acidalia Planitia.

Pedestal Craters: Pd are smaller than EE and Pr, generally ranging from <1 to 5 km in diameter. Pd are defined by having the crater bowl located near the center of a pedestal that is surrounded by an outward-facing scarp, which is generally several crater diameters from the rim crest [1,7]. The crater floors of mid-latitude Pd are generally above the elevation of the surrounding terrain, but often below the elevation of the pedestal surface [7]. Pedestals tend to be ~20 to 110 m in height [11], and are usually much more extensive than the reach of the ejecta, which is always SLE when visible [1,7]. A global survey revealed that the highest Pd concentrations are in Utopia and Acidalia Planitia, and Malea Planum [7].

Discussion: We believe the most important distinctions between these crater types are the diameter ranges and the ejecta morphologies. EE and Pr have roughly the same size range, and show minimal differences in geographic distribution and ejecta morphology. The most significant difference between EE and Pr is the infilling of the crater bowl, which is a secondary process (see Fig. 11 in [4], and Fig. 13 in [2]). *Meresse et al.* (2006) note that very few Pr are greater than 10 km in diameter because it is more difficult to fill the crater bowl completely.

By comparison, Pd are smaller, never have DLE, and are abundant in the southern hemisphere despite having the highest concentrations in the northern hemisphere. We have identified several Pr (>5 km in diameter) with DLE in the southern hemisphere, but have yet to confirm the presence of EE there. Perhaps the most significant feature that distinguishes Pd from Pr and EE, however, is that Pd always have a continuous, outward-facing scarp (see Figs. 6 and 10 in [7]). Topographic profiles of Pr and EE show that for the majority, the ejecta gradually slopes downward into the surrounding topography or ends with a rampart (Figs. 1-3b). The smooth pedestal surface and well-defined scarp that characterize Pd are likely the result of atmospheric/thermal armoring of the proximal surface upon impact [7,12] (see Fig. 17 in [7]), which contrasts with the often blocky ejecta covering that preserves ice-rich material in Pr and EE. Despite these differences, it is important to note that pedestal heights in Pd and excess ejecta thicknesses in EE are almost identical. This suggests that the crater morphologies are likely preserving the same type of ice-rich deposit.

Conclusions: From our observations, we conclude that: (1) EE and Pr are genetically related, and likely form from the same mechanism. The primary difference between these morphologies is simply that Pr have experience post-impact infilling, resulting in extremely shallow crater depths. (2) Given the diameter ranges of EE and Pr, and the estimated thickness of the mid-latitude ice-rich deposit during periods of high obliquity (10s to 100s of meters [2,7,10,11]), these impacts overwhelmed the ice-rich layer, penetrating to the underlying martian regolith. This resulted in the excavation of rock that formed the blocky ejecta necessary to preserve the ice-rich deposits. (3) The smaller size of Pd and the significant differences from Pr and EE in topographic profile requires that Pd result from a slightly different process. While the ice-rich target material may be identical for all three morphologies, Pd differ in that they do not penetrate through the ice-rich surface layer, and thus do not generate a blocky ejecta covering. Instead, they rely on a thin (centimeters to meters), indurated, dusty lag deposit to protect the underlying ice-rich material.

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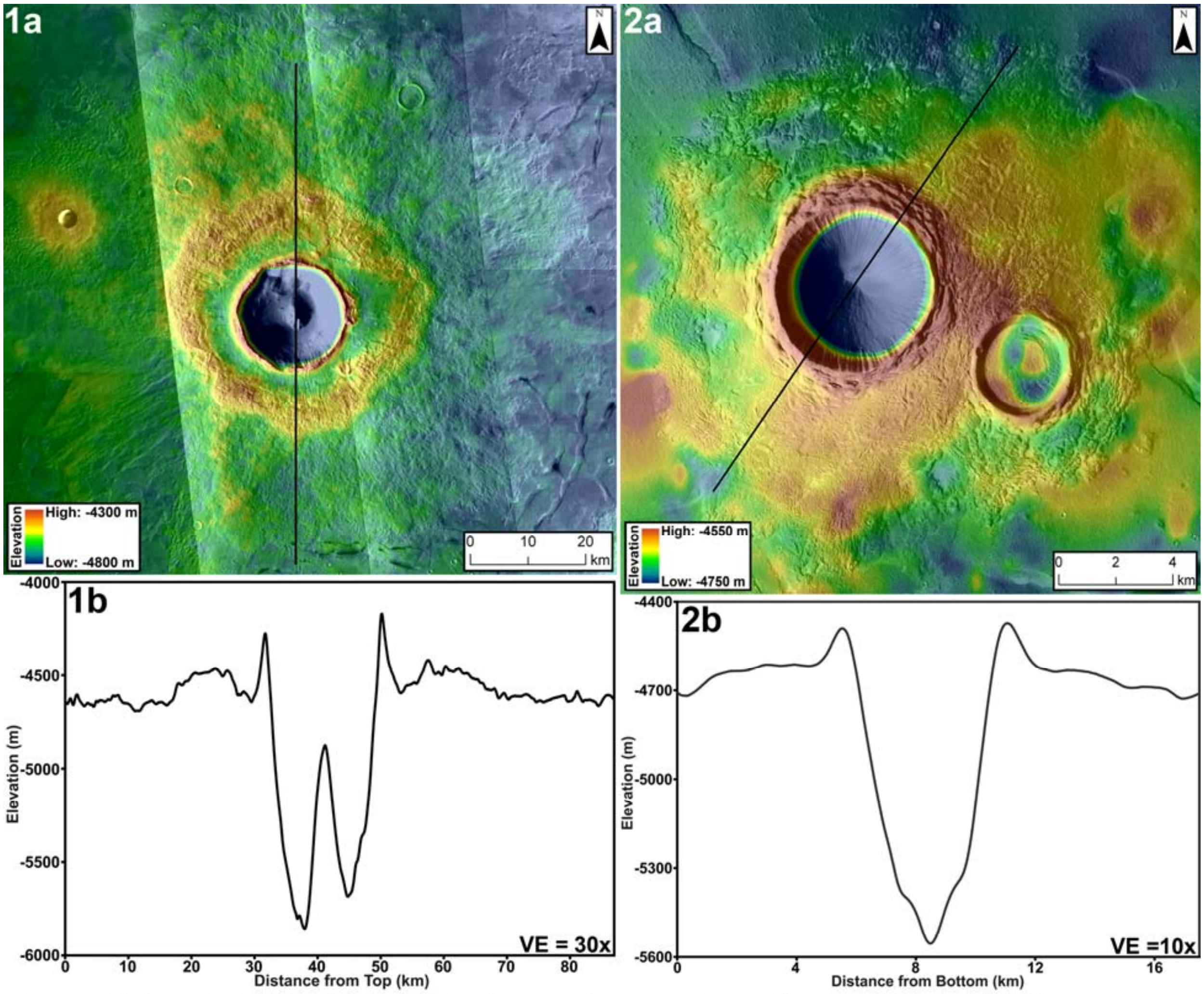

Figures - CTX mosaics with HRSC HiRes DTMs and corresponding topographic profiles derived from the DTMs for:
1) An EE at 99.2°N, 38.5°E with a central pit and DLE. The crater is 18.5 km in diameter and has excavated to a depth of ~1.2 km below the elevation of the surrounding terrain. **2)** An EE at 107.4°N, 32.8°E with minor infilling and SLE. The crater is 5.6 km in diameter and has excavated to a depth of ~0.8 km below the elevation of the surrounding terrain. **3)** A Pr at 46.3°N, 269.9°E with concentric crater fill and DLE. The crater is 4.8 km in diameter, and has been significantly filled, resulting in a crater bowl that is at the same elevation as the ejecta. For topographic profiles of Pd, see Figs. 6 and 10 in *Kadish et al.* (2009).