TYPE 1 EJECTA CRATERS ON MARS: NOT RESTRICTED TO JUST THE DOUBLE LAYER EJECTA MORPHOLOGY. N. G. Barlow, Dept. Physics and Astronomy, Northern Arizona University, Flagstaff AZ 86011-6010; Nadine.Barlow@nau.edu.

Introduction: In recent years, the Mars crater community has begun to recognize that there are distinct morphologic and morphometric differences in the layered ejecta blankets of craters in the lower latitudes versus those in the mid- to high-latitude regions (Fig. 1). This difference was first noticed for the double layer ejecta craters (DLE), where the higher latitude versions (“Type 1 DLE craters”) generally displayed an inner ejecta layer that is thicker and less sinuous than the outer layer [1-3]. Further analysis of these craters with high-resolution image sets and topographic data revealed the presence of a moat immediately exterior to the crater rim, straight radial grooves and ridges not deflected by pre-existing topography on the inner ejecta layer, and a broad rampart terminating the inner ejecta deposit [4-6]. These are in contrast to the lower latitude single layer (SLE), DLE, and multiple layer (MLE) ejecta craters which show similar thickness and sinuosity between layers, terminate in a narrow rampart, display radial grooves and ridges which are deflected by pre-existing topography, and show no signs of a moat.

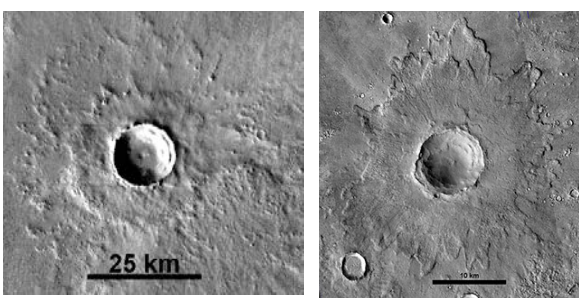

Figure 1: Left: A 14.3-km-D Type 1 DLE crater (38.05°N 213.66°E). Right: A 9.1-km-D Type 2 DLE crater (41.47°N 4.89°E).

The distinct differences between Type 1 DLE craters and the lower-latitude Type 2 craters has led to several proposals for a different formation mechanism of the Type 1 craters. These include (1) excavation through layered targets of differing volatile contents [7], (2) formation of the inner ejecta layer through a base surge mechanism [3], (3) excavation through a decameters-thick layer of ice-rich surface deposit followed by rim collapse to create the inner ejecta layer [8], and (4) shock-induced melting and vaporization of ground ice to create the outer ejecta layer followed by rim collapse to create the inner ejecta deposit [9]. Determining if the Type 1 morphology only occurs for the DLE craters or if other ejecta types also display the characteristic morphologies/morphometries will provide additional insights into the formation of these ejecta deposits.

Type 1 MLE Craters: Type 1 DLE craters dominate among the layered ejecta morphologies at latitudes poleward of about 35°-40° latitude in both hemispheres [10]. Traditionally, studies of the Type 1 characteristics have focused solely on the DLE craters for this reason. Most members of the Mars crater community have simply looked at the general form of the inner ejecta deposit to classify the crater as a Type 1 DLE crater, with little analysis of the outer ejecta deposit(s). However, as we have looked closely at some of the outer ejecta layers for craters classified as Type 1 DLE craters, we have noted cases of multiple partial ejecta layers, which should lead to these craters being classified as MLE craters. An example of this is 12.4-km-D Steinheim crater (54.57°N 190.65°E), which is often presented as an excellent example of a well-preserved Type 1 DLE crater [9]. Close inspection of CTX images of the northern part of its ejecta deposit clearly show the characteristics of a Type 1 inner ejecta deposit surrounded by a complete outer ejecta deposit with multiple partial ejecta layers beyond the inner ejecta layer (Fig. 2). The definition of a MLE crater [11] is as follows: “Layered ejecta crater surrounded by three or more complete or partial layers of material shall be called ‘multiple-layer ejecta’ (MLE)”. Hence, Steinheim is an example of a Type 1 MLE crater. This indicates that the Type 1 morphology is not restricted simply to DLE craters.

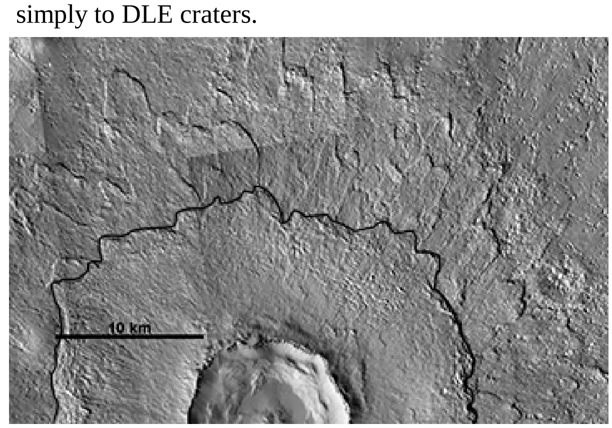

Figure 2: This CTX mosaic of the northern half of Steinheim crater shows a multiple layer ejecta morphology beyond the inner ejecta deposit (black line).

Type 1 SLE Craters?: The realization that there are examples of Type 1 MLE craters leads to the question of whether there also are Type 1 SLE craters on Mars. Pancake (Pn) craters, defined as "layered ejecta patterns that terminate in a concave slope" [11], are known to exist in the same latitude zones as the Type 1 DLE craters [10]. The similar morphologic appearance of Pn craters to the inner ejecta layer of Type 1 DLE craters led Costard [12] to propose that Pn craters were eroded versions of Type 1 DLE craters where the outer ejecta deposit had been removed. Subsequent analysis using higher resolution image and topography data showed that Pn craters display many of the same morphologic and morphometric characteristics of the Type 1 DLE inner ejecta layer and in some cases a faint trace of an outer ejecta deposit was noted [13-14]. This seemed to confirm that Pn craters were simply the inner ejecta deposit of Type 1 DLE craters where the outer ejecta layer was not detectable either due to erosion or image resolution.

However, during the revision of the Barlow *Catalog of Large Martian Impact Craters* [15] we noted very pristine Pn craters with no evidence of any outer ejecta deposit (Fig. 3). I propose here that not all Pn craters are eroded versions of Type 1 DLE craters, but rather than some are a Type 1 SLE craters.

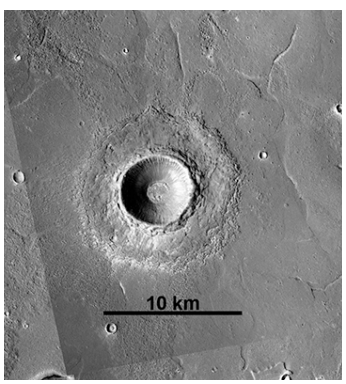

Figure 3: This fresh 5.0-km-diameter pancake crater (32.19°N 103.86°E) shows no evidence of an eroded outer ejecta layer. (CTX mosaic)

Conclusions and Future Work: Close examination of high resolution image and topographic data reveal that Type 1 characteristics are exhibited not only by DLE craters but also MLE and SLE craters at mid-to-high latitudes. This expands the number of Type 1 craters available for analysis and will help provide some constraints on the proposed formation models for these craters. The next step is to revise the layered ejecta morphology classifications in Barlow's *Catalog of Large Martian Impact Craters, v. 2* [15] to determine whether each crater can be classified as a Type 1 or a Type 2 SLE, DLE, or MLE. This will involve detailed measurements of features such as the rampart widths, linear groove widths as a function of distance from the crater rim, determination of the presence/absence of a moat, etc. This database will then allow us to investigate the distributions of the Type 1 and 2 craters to determine how the local environment influences the production of the observed features. This analysis also will determine if there are more than two types of layered ejecta deposits, as was suggested by [16] based on a preliminary investigation of craters in the northern hemisphere. The database also will allow us to test the various proposed formation models for Type 1 DLE craters to determine if they also can explain the Type 1 SLE and MLE craters.

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