VISIBLE AND THERMOPHYSICAL MAPPING OF CRATERS WITH TRANSITIONAL MORPHOLOGIES: INSIGHTS INTO THE NATURE AND EXTENT OF CRATER DEGRADATION ON MARS.

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Introduction: Crater degradation on Mars is a consequence of various mechanisms which may have waxed and waned (*e.g.*, fluvial, volcanism, etc.) or even grown more influential over time (*e.g.,* aeolian, periglacial, etc.). Furthermore, crater degradation can vary at the local (*i.e.,* crater-scale) or regional scale on Mars [1-9]. To recognize the nature and extent of the degradation mechanism(s) involved, a 'baseline' or 'initial' crater state, based on the best-preserved craters on Mars, must be defined as it is from this "initial" state that the net effects of erosion and deposition are recorded by the impact crater since the time of its formation.

Previous work indicates that the best-preserved impact crater baseline, within both a thermophysical and morphological framework, is necessary to improve our understanding of the impact processes and subsequent crater degradation [9-11]. The overarching goal of this research is to assess the nature and extent of impact crater degradational processes (*i.e.* erosion/deposition) on Mars by investigating the following objectives: 1. Identifying the physical and thermophysical characteristics associated with well-preserved impact craters; and how they compare to degraded craters, and 2. Assess the role of the target rock materials on detailed crater morphology and the effects of crater modification, if any.

Herein we report on the initial results of detailed mapping and comparative analysis of craters with simple-to-complex transitional morphologies (*i.e.*, 4 < D < 8 km), including both best-preserved and slightly degraded examples.

Background: Tornabene et al. and Piatek et al. [9, 11, 14-16] has built a framework upon which the effects of crater degradation can be determined. This is accomplished by first defining a 'baseline' using detailed morphologic and thermophysical mapping, which compares the best-preserved craters with a degraded one of similar size, where both craters are within a specific target type (*i.e.*, defining the baseline for that target material). Selecting craters on the same target material is fundamental, as the nature of the target rock (*i.e.*, weak vs. strong target materials) may influence both the initial and post-degradation characteristics of craters. Through this approach, the effects of the processes of erosion and deposition on impact craters on Mars can be recognized, quantified and understood.

Five transitional craters were selected for this study: Resen (D = 7.6 km; 108.88°E, 27.34°S), Noord (D = 7.8 km; 348.74°E, 19.27°S), an unnamed crater that we refer to as "Near Resen" (D = 7.5 km; 115.67°E, 25.79°S); Gasa (D = 7.2 km; 129.41°E, 35.72°S) and Istok (D = 4.6 km; 274.18°E, 45.10°S). Resen and Noord are amongst the best-preserved transitional craters on Mars [10-12, 17] formed in coherent lavas and heavily cratered terrain, respectively. "Near Resen," Gasa and Istok are all well-preserved but slightly degraded craters. "Near Resen" was selected as it occurs near Resen (~400-km apart) and it's slightly more degraded, with both craters occurring in Hesperia Planum.

Given some basic assumptions about impact conditions, their similar size and state of preservation, but different target properties, we suggest that mapping and subsequent comparisons of Resen and Noord will provide: 1. The definition of two best-presered morphologic and thermophysical baselines for transitional craters – one for each target material (*i.e.,* younger Hesperian lava plains and heavily-cratered Noachian terrain), and 2. Insights into the role and effect of different target materials on the impact process, and subsequent degradation processes. In regards to Resen and "Near Resen," it is fortunate that these two craters are similar in size and interpreted to be in the same target materials. Bearing in mind a few assumptions, a comparative analysis will aid us in isolating signatures associated with the type(s) and extent(s) of degradation, that recently took place in Hesperia Planum.

Although Gasa and Istok are rather young and well-preserved craters [9,18], they display a range of extensive aspect-dependent (*e.g.,* pole-facing slopes) degradation processes. Gullies in Gasa are amongst the most active observed on Mars to date [19], and Istok contains dry mass-wasting, debris flows and possible gully activity [19, 20]. As a result, they present a unique opportunity for comparison, since the majority of their degradation occurs only on the pole-facing slopes, while opposing slopes are extremely well-preserved. As such, these craters can be compared to our best-preserved transitional crater baselines as well as themselves.

Methods: The acquired Mars datasets for our selected transitional craters are imported into ArcMap software in order of spatial scale: 1. HiRISE, 2. CTX, 3. THEMIS (including THEMIS-derived TI if available), and 4. MOLA gridded digital elevation model as a base

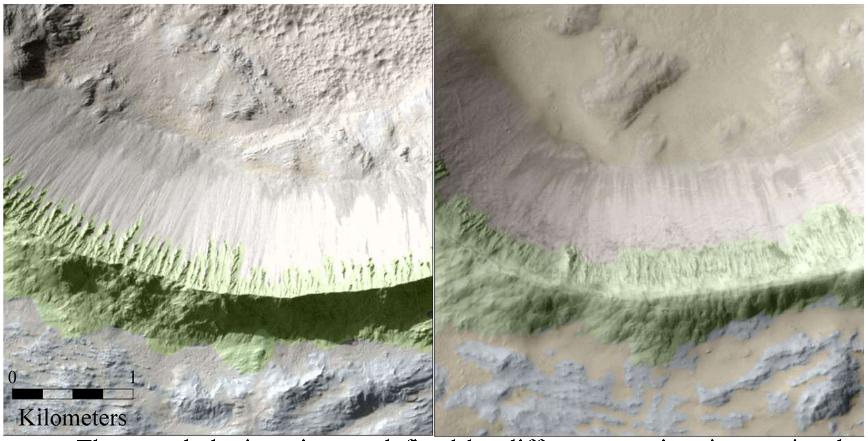

Figure 1: Resen (Left) and "Near Resen" (Right) morphologic mapping with CTX as basemap. Similar colours in both panels are mapped as similar morphologic units (*e.g.,* crater rim/wall, etc.). The difference in incidence angle between these two images is only approximately 6º. As such, differences are mainly attributed to morphology rather than differences in lighting. In general, "Near Resen" has a less sharp and muted appearance due to degradation.

map. The morphologic units are defined by different attributes, resolvable on a meter- to decameter scale: texture, tonality, structures/features, relief, and by the unit's relationship to its surroundings (*e.g.*, other units and topography). Colours are used to represent different geologic units where there was some interpretation following an initial strictly morphologic mapping, followed by consolidation of the strict morphologic units based on inferred origins of the unit (*e.g.* crater-related pitted material has both a smooth and pitted facies) and lack of clear stratigraphic relationships. These differences in morphology within an individual unit were then subsequently represented as facies through using stylized or textured shapefiles. For instance, all the crater-related pitted material are mapped as orange, but overlapping the coloured units are textured units used to represent various textures or facies within an interpreted geologic unit (*e.g.* smooth, flowing, ponded, etc.). Textured shapefiles were also used to map where superposed materials that effect thermophysical properties, such as aeolian.

Results: Morphologic mapping on Resen and Noord, excluding the discontinuous ejecta, resulted in the definition of 11 units and facies, which correlates well with relatively consistent thermophysical characteristics [13,14]. These units and facies are relatively consistent between the two craters, but we observe some morphologic and thermophysical differences, which we attribute to target effects (*e.g.,* size and distribution of slump blocks, etc.).

Mapping of Resen and "Near Resen" reveals obvious differences in degradation state (*e.g.,* Fig.1). Overall, "Near Resen" has smoother and more subdued features when compared to Resen (*e.g.,* "sharpness" of crater rim crest). Whether deposition or erosion was the responsible mechanism for these observed morphological differences is an area of further investigation (*e.g.,* infilling of crater floor vs. smoothened rim crest)]. Although Gasa and Istok are only partially mapped, at an initial overview they reveal morphological and thermophysical differences that we attribute to the difference in the type of degradation processes (*e.g.,* high thermal inertia associated with the alcove of gullies). Additional insight into the thermophysical nature of these craters will be provided and discussed by Piatek et al. [see 21].

Future work: Mapping of the discontinuous ejecta of Resen and Noord and progress on the morphologic mapping of Gasa, Istok, and "Near Resen" is ongoing. Following the completion of mapping, detailed comparative analysis between these craters will continue to reveal qualitative (*e.g.,* sharpness of rim crest, etc.) and quantitative differences (*e.g.*, rim/cavity wall curvature/slope, changes in thermal inertia, planimetric symmetry, etc.). In turn, the quantitative parameters we measure will allow us to determine the extent and nature of the associated degradation processes. Since discernable morphologic features and thermophysical characteristics may be possible at smaller scales; we aim to include mapping and analysis of Zumba (D = 2.9 km; 226.94°E, 28.68°S), as it is one of the best-preserved simple craters on Mars [9-11, 22].

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