MODIFICATION OF MARTIAN CRATER EJECTA FACIES OBSERVED IN THERMOPHYSICAL DATASETS.

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Introduction: Expanding on previous work that examined the visible morphology [1] and thermophysical properties [2] of "well-preserved" Martian craters near the transition diameter, we explore changes in ejecta facies as a function of crater degradation. Initial studies focused on craters between 1 and 10 km in diameter considered "well-preserved" based on criteria such as depth/diameter, morphology, and presence of easily-eroded ejecta deposits like rays and pitted materials. The goal of this renewed work is to identify changes in thermophysical, morphologic, and/or photometric character associated with post-crater formation modification deposits.

Method: Ejecta facies were defined using maps of both quantitative thermal inertia (TI) (derived from THEMIS nighttime infrared data [3]) and geomorphology (based on high-resolution visible imagery [1]). A consistent set of unit definitions and map features were employed during this process to enable correlation of map units across multiple datasets: simplified versions of these definitions are presented in Table 1. Statistics of quantitative TI values were obtained from polygonal regions of interest based on these map units via feature analysis tools in ArcGIS and ENVI/IDL.

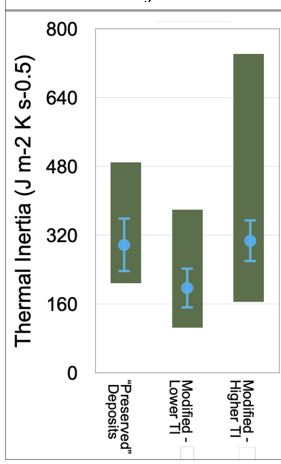
***Table 1**. Thermophysical facies definitions. "High" and "low" are relative to nearby units and the target.*

Unit	Criteria for Mapping
Crater Floor	All "low" TI material interior to crater walls. May include small areas of higher TI slump materials.
Crater Walls	All "high" TI areas corresponding to 'circular' crater wall/rim materials. May include small areas with low TI.
Thermally Continuous Ejecta	Adjacent to crater walls, typically has a distinct thermophysical margin that is also identifiable in daytime IR.
Thermally Discontinuous Ejecta	Apparent extent of thermophysically distinct radial ejecta and airblast scouring. May be subdivided (inner/outer) if two distinct thermophysical signatures are present, or not (mixed).
Included Craters	Craters within ejecta units that have distinct thermophysical patterns but unlikely to be secondaries due to size.

Preliminary Results: Initial examination of morphologies visible in the CTX mosaic provided by [4] suggests that observed changes in surface character can be attributed to modification and are correlated with changes in thermophysical character. These changes in morphology are associated with variations in the overall ranges of TI values extracted from unit statistics, in addition to variations in the spatial extent of discontinuous ejecta facies.

Thermally continuous ejecta: This unit was identified in thermophysical mapping initially as ejecta adjacent to the crater rim with a thermally-distinct outer margin; it is worth mentioning that this margin is not equally distinct for all mapped craters. This unit was identified at all mapped craters, suggesting materials that are relatively resistant to erosion, and typically extends to a few crater radii from the crater rims. Where present, the thermally distinct outer margin is coincident with the edge of layered ejecta facies in visible images. Often, beyond the margin of this unit is a thermally darker facies that appears to coincide with a continuous ejecta facies that extends beyond the layered ejecta [1,5].

***Figure 1**. TI statistics for continuous ejecta units.*

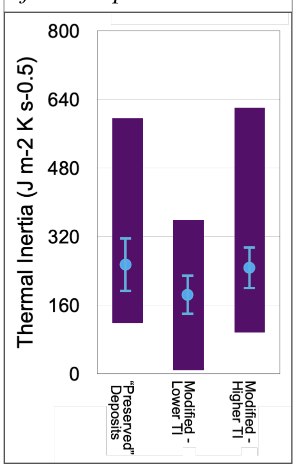


Thermal inertia values for thermally continuous ejecta units are typically moderate (200-500 in m.k.s. units), indicating a relatively cohesive deposit. Continuous ejecta at less well-preserved craters may have overall lower TI, suggesting deposition of finer materials overtop, or may have experienced removal of fine grained material, expanding the overall range of TI values, predominantly to higher values (see Figure 1, where colored bars indicate ranges of TI values across mapped craters, and the data point indicate the average with 1-sigma error bars).

Thermally discontinuous ejecta: This unit is defined by an overall radial appearance and a location outside the continuous ejecta facies. This radial character can be mapped past 10 crater radii from the rim, even when crater rays are not identified, but the extent of discontinuous ejecta becomes smaller with increased modification/decreasing preservation. This unit was particularly difficult to identify at the least-preserved crater mapped in previous work (Kontum). Typically this discontinuous ejecta can be subdivided into two distinct units: an inner discontinuous ejecta unit that is thermally bright (higher relative TI) and an outer discontinuous ejecta that is thermally dark (lower relative TI). At some of our mapped craters, notably those with intervening topographic obstacles, the discontinuous ejecta consists of one unit with "interfingered" (or mixed) thermophysical variations (thermally bright and dark material).

As with thermally continuous ejecta, there is a variation in the range of mapped TI values that could be attributed to either addition of fine-grained material (overall decrease of TI values) or exposure of more cohesive materials/ removal of fined-grained material (an overall increase in TI values with modification). For discontinuous deposits that are mixed (consisting of both higher and lower TI radial materials; see Figure 2), the overall range of values does not tend to change, but rather moves to generally lower or higher TI values.

***Figure 2**. TI statistics for "mixed" discontinuous ejecta map units.*



Where two thermally distinct discontinuous ejecta facies are present (see Figure 3), the "inner" deposits exhibit changes similar to deposits mapped as "mixed" - the overall TI values increase or decrease but the overall range does not tend to change significantly. The most distal discontinuous ejecta facies ("outer" units, typically lower TI than "inner") experience an increase in overall TI range likely due to preferential removal of finer-grained material and exposure of more coherent surfaces by modification, a process that likely also contributes to decreasing the extent of these deposits.

Conclusions: Preliminary examinations of thermophysical character of Martian craters with different preservation states suggest that there are quantifiable thermophysical changes in ejecta facies with modification. Ongoing work will focus on identification of changes in morphology and/or photometry in high-resolution visible imagery with the goal of identifying potential modification processes responsible for these changes. If successful, this should eventually result in development of a relative chronology for ejecta deposits as they are affected by various ongoing modification processes.

References:

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[3] Piatek, J.L.. et al., 2017. *LPSC* 48**,** #2752.
[4] Dickson et al., 2018. *LPSC* 49, #2480.
[5] Tornabene et al., 2019. *9th Int'l Mars Conf.*, #6354.

***Figure 3**. TI statistics for discontinuous ejecta with thermally distinct "inner" and "outer" facies.*