MAPPING THE NORTHERN PLAINS OF MARS: USING IMPACT CRATER MORPHOLOGIES TO RESOLVE SURFACE GEOLOGY WHEN CONTACTS ARE SPARSE. J. A. Skinner, Jr.[1], T. Platz[2], M. R. Balme, S. J. Conway, F. Costard, C. Gallagher, S. van Gasselt, E. Hauber, A. E. Johnsson, A. Kereszturi, A. Losiak, C. Orgel, J. D. Ramsdale, D. Reiss, A. Séjourné, Z. Swirad, [1]Astrogeology Science Center, U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ, 86001 (jskinner@usgs.gov),[2]Planetary Science Institute, 1700 E. Fort Lowell, Tucson, AZ, 85719.

Introduction: Geological mapping investigations can be complemented by systematic landform analyses, particularly in regions where unit contacts are poorly observed or absent. A case in point is the Martian northern plains, where clearly-defined superposition relationships between discrete geological units are sparse, resulting in approximate or inferred contacts that delineate relative changes in the densities of common (typically secondary/ erosional) landforms [1-6]. However, landform analyses themselves are often muddled by (1) the concurrent and gradational nature of many landforms, (2) significant areal variations in landform types, and (3) an insensitivity of small-scale (large area) mapping to the subtle distribution of local landforms. This latter point is particularly important due to the prominence of interpreted ice-related features throughout the Martian northern plains [*e.g.*, 5-7].

An International Space Science Institute (ISSI) team has been convened to investigate the locational variability of regional- to local-scale landforms in three 300 km-wide latitudinal strips in the Martian northern plains [8] (Acidalia [9], Arcadia [10], and Utopia Planitiae [11]). The goal is to ascertain whether systematic classification of lowland landforms can help constrain geological processes and/or units, particularly in relation to the periodic enrichment and removal of subsurface ice reservoirs [8]. Here, we present methods and preliminary results of a component of this team-based research: a revised classification of impact craters.

Method: Global impact crater classification schemes [*e.g.*, 11-13], though broadly useful, have inherent limitations due to fitting a gradation of observations into static boundaries. We postulate that a regional (rather than global) scheme may be more sensitive to changes that occur in unique physiographic provinces by avoiding the totality of classes more relevant to a global scheme. Can we devise a repeatable crater classification scheme that is simultaneously sensitive to crater morphology (ejecta, rim, interior wall, and floor) and the elevation of surrounding terrain?

Using ArcGIS, we extracted all impact craters ≥2 km diameter from the global crater catalog of [14] for each region of interest. We examined the ejecta, rim, interior wall, and floor of each crater for existence, continuity, and relative topographic position using the MOLA, THEMIS daytime IR, and CTX data sets at 1:500K scale (for D>5 km) and 1:250K scale (for 2≤D<5 km). We deleted points that were part of larger clusters, were located in data gores, or were deemed to lack definitive impact morphologies. This "first-cut" assessment helped to identify where past global crater classification schemes were insufficient to describe the range of crater morphologies in the Martian northern plains, such as sole attendance to ejecta morphology [13] and scale-based interpretation of "preservation state" [14]. Leveraging these limitations, we devised a new scheme (**Fig. 1**), which we applied to all craters in the three regions of interest.

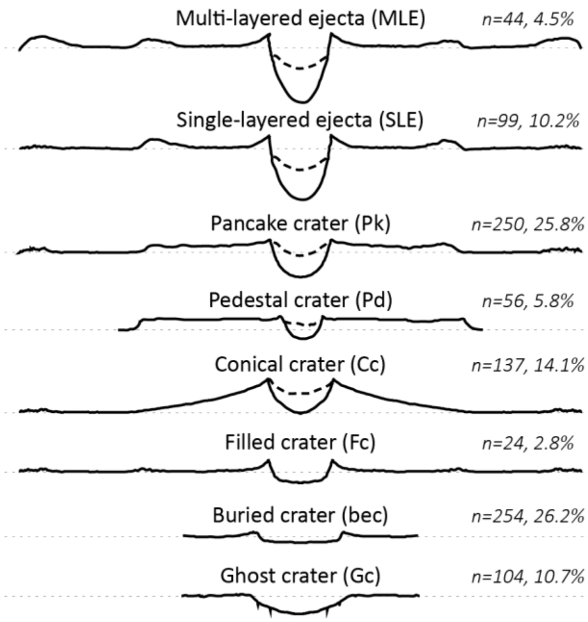

Figure 1. Crater classification scheme for impact craters with D≥2 km in the Martian northern plains, adapted from past approaches [11-13] using the global catalog of [13]. Numbers presented are composites for craters in all three regions located between 30 and 80°N latitude (n=968).

Our newly-devised classification scheme uses definitions based on the morphologic and topographic character of impact ejecta (*e.g.*, presence of layers, continuity of marginal ramparts, existence of lobate and (or) radial textures), crater rim (*e.g.*, crispness, continuity, interior-exterior slope asymmetry), and interior floor (*e.g.*, shape in cross-section, presence of primary textures, elevation relative to surrounding terrain). Therein, an impact crater with a single layer of continuous ejecta that is circular (not lobate), a rim that is subdued and symmetrical, and an interior floor that is gently bowl-shaped and near the elevation of the surrounding plain would be classified as "Pk – pancake crater". Similarly, an impact crater with no ejecta, a rim that is discontinuous and features a steep inward-facing scarp, and a flat floor located near the elevation of the surrounding plain would be classified as "bec – buried/eroded crater" (**Fig. 1**).

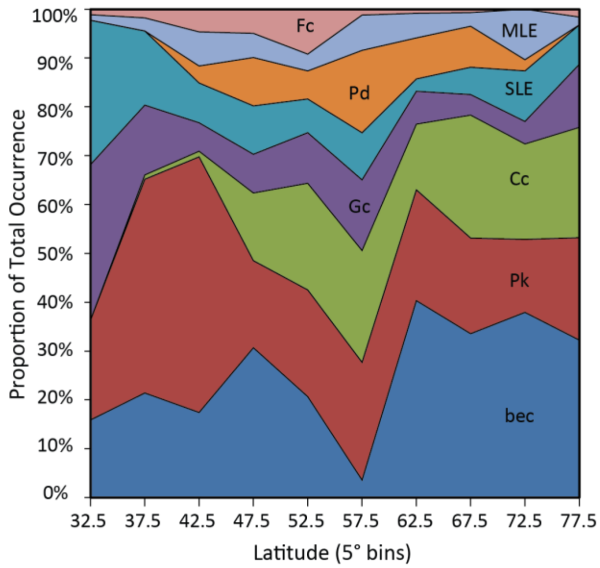

Figure 2. Composite proportions of all classified craters (n=968) within the Acidalia, Arcadia, and Utopia regions of interest. Note the preponderance of bec, Pk, and Cc classes (66% of total), mid-latitude occurrence of Pd, and the anomalous drop in bec craters between 50° and 60°N latitude.

Results: We have classified all impact craters with D≥2 km in the three regions of interest in the Martian northern plains. Though quality assurance efforts are ongoing, here we present composite details of the 968 impact craters that exist between 30° and 80°N latitude in the Acidalia, Arcadia, and Utopia regions of interest. Buried/eroded (bec), pancake (Pk), and conical (Cc) craters (**Fig. 1**) make up ~66% of the total composite population (**Fig. 2**), suggesting both pervasive deposition (*e.g.*, flattened and (or) elevated interiors across a range of diameters) and erosion (*e.g.*, absence of ejecta and rims) within broad swaths of the Martian northern plains. Emplacement – then removal – of a decameter-thick unit in parts of the lowlands is also supported by the preponderance of pedestal craters (Pd) between 40° and 75°N latitude (**Fig. 2**) and at D<4 km, confirming previous work [15]. Additionally, our early assessments also show a steady (though low) proportion of impact craters with continuous marginal ramparts and asymmetric rims (MLE and SLE; **Fig. 1**) across all latitude ranges (**Fig. 2**), a possible testament to not only the long-lived availability of subsurface volatiles but also the steady degradation of these landforms across latitudes and regions. Finally, we note that our results thus far help identify areas to re-examine for accuracy, such as the anomalous proportional drop in buried/eroded craters between 50° and 60°N latitude.

Next Steps: The cross-sectional and planimetric shape of impact craters and related materials provides an invaluable tool for identifying the spatial and temporal character of impacted strata and interstitial volatile reservoirs Our efforts to classify impact craters based on collective assessment of ejecta, rims, interior walls, and floors appear to support the application of a repeatable crater classification scheme for the Martian northern plains. Full determination of the existence (or absence) of systematic trends potentially supportive of geological units and processes will result from close comparison to grid-based landform efforts of [8-11]. Results presented herein will be refined by:

- Normalization of crater classes independently assigned by authors for study areas, which will tighten class definitions and improve analytical accuracy.
- Assessment of trends in all ISSI team-based landform mapping efforts [8-11], which has the potential to provide previously unresolved details regarding climate-related geological units and processes in the Martian northern plains [*e.g.*, 5-7].
- Direct comparison of our scheme to past geological maps [1-7] and global crater classification schemes [12-14], which will yield details on the value of a regional vs. global crater classification as a map tool.

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