TARGET PROPERTY CONTROLS ON MARTIAN IMPACT CRATER MORPHOLOGIES. B.M. Hynek[1-2] and R.R. Herrick[3], [1]Laboratory for Atmospheric and Space Physics, University of Colorado-Boulder, 3665 Discover Drive, Boulder, CO 80303, [2]Dept. of Geological Sciences, University of Colorado-Boulder, [3]Geophysical Institute, University of Alaska, 903 Koyukuk Drive, Fairbanks, AK 99775 hynek@lasp.colorado.edu

Introduction: Impact cratering is the most ubiquitous geologic process across the solar system and the resulting craters provide inferences into target and impactor properties. Yet separating the varied contributions of target and impactor to final crater form is a formidable task. Here, we explore effects of Martian target properties on the cratering process using a global crater database and recent geologic map. In a companion abstract [1], we characterize impactor influences on final crater form.

Hypothesis, Data Sets, and Methods: Our hypothesis is that a planet's target properties influence final crater form. We tested this hypothesis by conducting a global examination of Martian impact craters from [2] compared with geological units defined by [3] and our own assessment of fine scale geologic relations and units, following up on an initial study in [4]. The effects of target properties during the impact process, including the strength of crust, layering, and volatile content (among other factors), have previously been studied through geologic studies, modeling, and experiments [e.g. 5-7]. Here, we take a new approach

We started with the assumption that craters of a given diameter had roughly the same impact energy and differences in crater form would be a result of either impactor or target properties. We studied craters with 7-9 km diameters, within the simple-complex transition range on Mars, in order to maximize crater variation for a near-constant impact energy. We selected all pristine craters on Mars (degradation state = 4) from the crater database of [2] (n = 574 craters) in an effort to minimize post-formation modification from erosion, etc. We used the existing classification of craters in this database that included simple, complex-central peak, complex-central pit, complex-summit pit, complex-flat-floored, and complex-unclassified. These were ingested into a GIS environment for comparison to the geologic map of [3] to assess geologic unit controls on crater form.

Results and Interpretations: We found that the local geology has a strong influence on crater form, although in some regions there is only a minor influence. Few pristine craters exist at latitudes above ±45°; likely due to polar/periglacial process and limiting our findings to low-mid latitudes. The following are major trends identified in our study.

Simple vs. complex: Pristine simple craters of this size range are preferentially found in the northern plains and on volcanic terrains (Tharsis and Elysium). Thus, we infer that simple craters in the 7-9 km diameter range formed on terrains that are rheologically strong and relatively homogenous to a depth of at least 1 km. Simple craters have somewhat of a spatial anti-correlation with complex craters, which are distributed throughout the southern highlands. We hypothesize that heterogeneities in the crust and local topography led to the varied complex crater forms. Complex craters of all classes are well-distributed, but types (flat floored vs. central peak vs. central pit) are geographically bound, in general.

Central pit craters: Central pit craters have a characteristic depression in their centroids and exist on Mars, Mercury, Ganymede, and Callisto. Numerous hypotheses have been put forth to explain central pit formation including subsurface volatiles, layered crust, or internal volcanic processes [e.g., 5,8]. We find that Martian central pit craters are anti-correlated with central peak craters. Additional, they are most abundant in volcanic terrains around major constructs (Tharsis, Syrtis, Elysium, and Hesperia). In fact, 48% of our central pit sample occur in volcanic units delineated by [3], while these volcanic terrains only represent 16% of the total surface area of Mars (Fig. 1). On the other hand, central peak craters are mostly absent from volcanic terrains, but do occur around the fringes (where units are presumably thin). Our interpretation is that

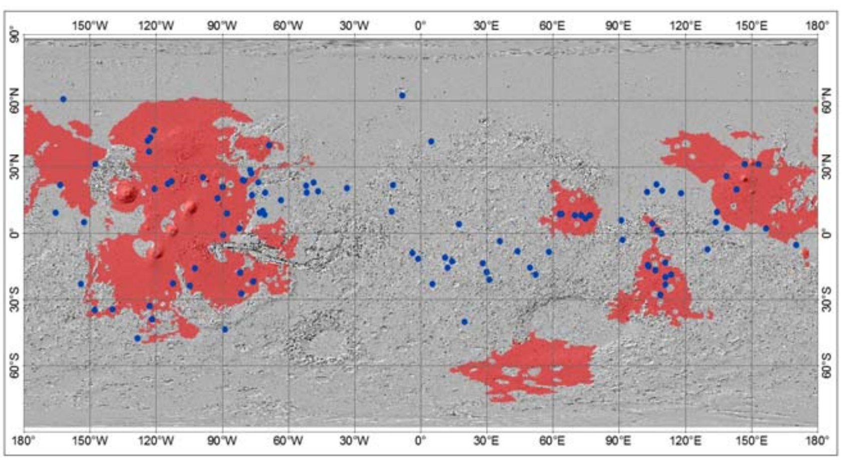

Figure 1. Distribution of 7-9 km pristine central pit craters (blue dots) from [2]. Red areas are vast plains composed of flood basalts [3].

the central pit craters in this size range occur from excavation in a layered target, perhaps layered basalt flows interspersed with weak tephra layers. The flat floor represents a hard layer, just underneath a weak layer, at the base of a nonparabolic transient cavity, with the central pit representing some minimal penetration into the hard layer (the "sombrero" model for excavation in a layered target). Our findings are not supportive of the subsurface volatile hypothesis [e.g. 8].

Flat-floored craters: This class of craters also has some spatial associations with geologic terrains and central pit craters. Roughly half are found in volcanic terrains, with the rest being in Isidis basin and along the lowland-highland transitional terrains, with a few peppered throughout the highlands. Close examination of these craters with CTX data show a significant fraction are flat-floored due to post-impact modification indicating that fewer craters form with flat floors than implied from “pristine” craters in the database.

Case study: Nepenthes region W-SW of Elysium: Fig. 2 shows a region of Mars with clear influence of target properties on resultant crater form. Represented are the pristine 7-9 km diameter craters from [2] on the geologic map and unit symbols of [3]. This area represents a transect from the northern lowlands, through the transition terrains, into southern highlands units. We confirmed that indeed the geologic units are properly mapped at the fine scale we used for our local investigations of the geology around these craters. A few craters were reclassified by type and those not appearing pristine in CTX images were removed. The northern plains materials representing layered sediments/ volcanics and volatile-rich fractured ground are covered almost exclusively by simple craters. A thick sequence of wet, fine sediments [9] that later consolidate could result in deep [10] simple craters. While clear evidence for a volatile-rich crust exist, central pits are absent. Central pits are instead found on the lava units in the central and southwest regions (tan and purple colors, respectively) of the map. The rough highlands terrains host most of the central peak craters and here and globally this class is mostly found on topographically rugged terrains of heterogeneously-mixed materials (e.g., impact ejecta, volcanics, sediments) and the transitional terrains (dark tan).

Conclusions: We used a diameter slice of pristine craters on Mars to test the importance of target properties on final crater form. The narrow range of diameters ensures a consistent impact energy and thus differences in form are in part a result of target properties. We found that particular classes of craters are correlated spatially and also with different geological terrains. Simple craters of this size range are found primarily in the layered northern plains and on layered lava flows. Central pit craters have an affinity for volcanic terrains and we infer weak (tephra?) layers interbedded in the lavas could explain the central pits. Central peak craters populate the rough highlands terrains and are lacking in smooth volcanic plains. This research suggests that target properties can exhibit strong control on the morphometry of the resultant crater.

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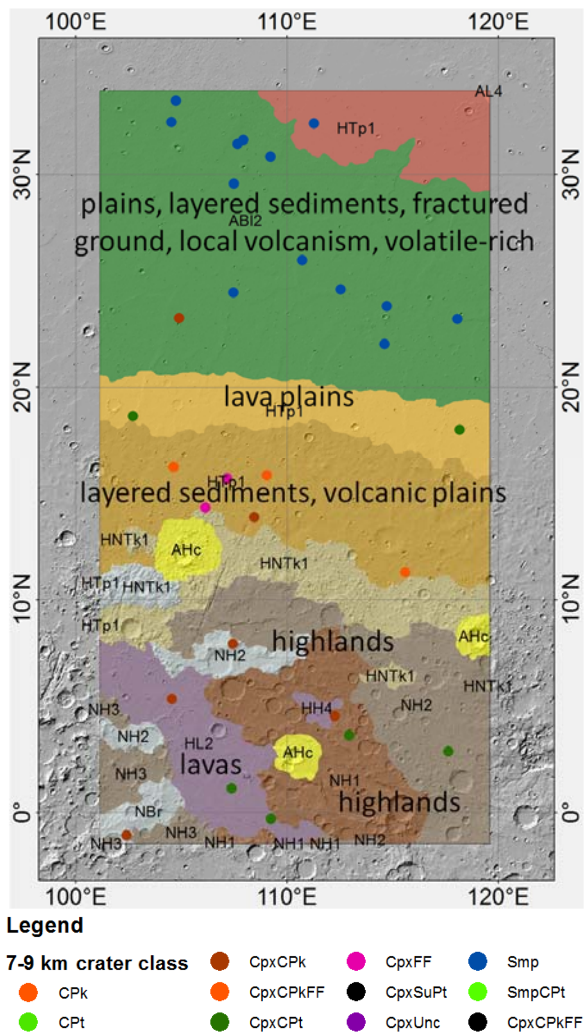

Figure 2. Nepenthes study region. Geologic units are from [3] and type of pristine 7-9-km-diameter craters are from [2]. In this region of Mars, clear spatial correlations exist between crater type and the local geology.