AGE-DATING OF ICE-RICH MID-LATITUDE MANTLE DEPOSITS ON MARS. D. Viola, NASA Ames Research Center, Moffett Field, CA.

Introduction: Shallow water ice is abundant throughout the mid-latitude plains of Mars [e.g., 1-6]. The deposition and removal of this ice mantle over time are thought to be cyclic and closely linked to climate [7], particularly to the planet's obliquity cycles [8-9]. Mantle dissection [10] and thermokarst-like features [e.g., 11-12] have been interpreted as evidence for the degradation of this mid-latitude ice over time.

Ice-rich mantle deposits appear to drape pre-existing topography, and have been interpreted as compressed snowfall, with a small fraction of incorporated dust/regolith [13]. They are thought to be geologically-young due to qualitative observations that few impact crater superpose the mantle material. This study aims to provide more qualitative constraints on the age of the surface mantle material by performing crater counts within the mapped extents of intact mantle units amongst or adjacent to regions that have experienced thermokarstic degradation.

Methods: Crater age-dating is commonly used to approximate the ages of planetary surfaces, based on the premise that older terrains will have accumulated more impact craters over time. Absolute age-dating requires some assumptions about the crater production rate; lunar crater distributions have been directly linked to radiometric dating of returned samples [e,g., 14], and those production functions have been extrapolated to other planets [15-16]. While it is challenging to use crater counting to age-date very small and/or very young surfaces [17], it can nonetheless provide reasonable constraints on the relative and absolute timing of geologic processes or events. It is important to ensure that craters are counted within single geologic units that likely formed simultaneously (as opposed to spanning multiple surface types). Since ice-rich mantle deposits drape pre-existing topography – including impact craters – it is also important in this context to only consider un-mantled impact craters that superpose the mantle deposits. If mantle-like material is present on a crater's ejecta or within the crater bowl, it will be excluded from crater counting data. An additional complication is the degradation of the mantle material by thermokarstic processes (post-dating deposition). Mapping of different terrain units will be performed to delineate regions where the mantle remains intact. While the sub-units of intact mantle can be geographically separate in cases where extensive degradation has occurred, those that possess similar characteristics will be interpreted as remnants of the same surface-blanketing unit. This will help to accumulate crater counting data over a sufficiently-large area for age estimation.

All mapping will be performed using images from the Context Camera (CTX) on the Mars Reconnaissance Orbiter, as this data set has near-global geographic coverage at fairly-high resolution (6 m/pixel) [18].

Study Areas: This study will focus on the northern mid-latitudes of Mars, primarily within Utopia Planitia and, to a smaller extent, Arcadia Planitiae (Figure 1). Utopia Planitia contains abundant scalloped depressions [e.g., 19], which are thought to be geologically-young. A subset of Utopia Planitia (~60,000 sq. km) has been identified for preliminary mapping work (Figure 1), and the results from a proof-of-concept test swath are shown in Figure 2.

Arcadia Planitia contains extensive secondary crater fields, a large part of which appears to have experienced post-impact thermokarstic expansion [20]. Therefore, crater age-dating in this region presents a unique challenge due to the high potential for secondary crater

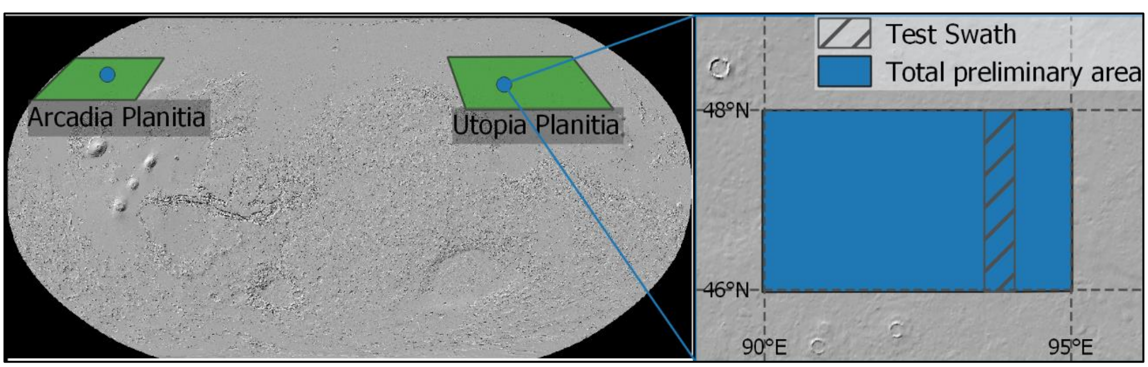

Figure 1: (Left) Global map of Mars showing areas of interest; blue points indicate approximate locations of the areas of interest relative to the overall extent of Arcadia and Utopia Planitiae (green regions). (Right) Utopia Planitia study area; striped region represents the extent of the preliminary test swath (mapping and age dating results for this swath are shown in Figure 2).

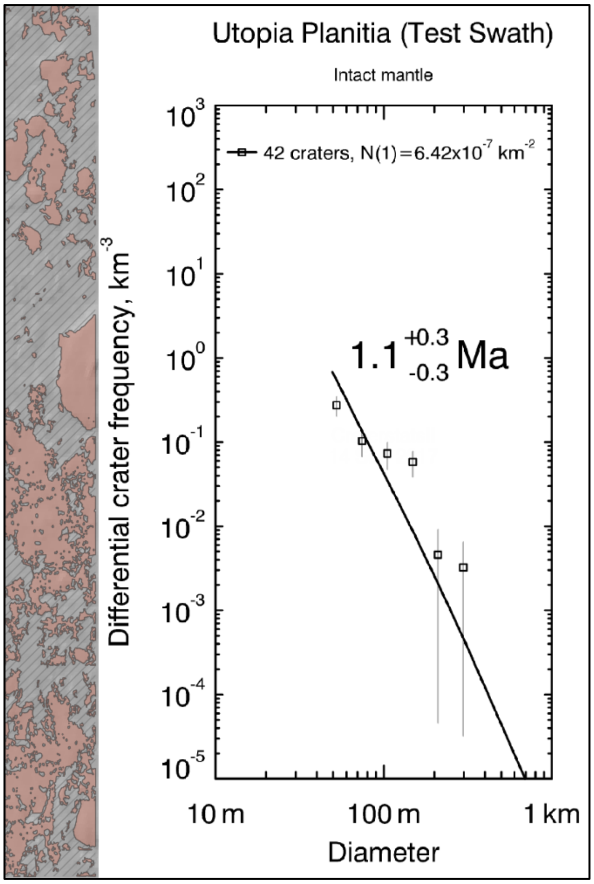

Figure 2: (Left) Intact mantle terrains in the 40-km-wide Utopia Planitia test swath (area shown in Figure 1), where red is intact mantle. (Right) Age-dating results based on craters superposed on the intact mantle regions throughout the test swath.

contamination. Ongoing work is being done to identify a sufficiently-large region of intact mantle (outside of the denser rays of secondary craters) adjacent to and similar in appearance as a thermokarstically-degraded surface. These characteristics will help to indicate that the surfaces are likely part of the same original topography-draping unit, while ideally minimizing the potential for secondary crater contamination. Once one or more appropriate regions are identified, crater counts and age-estimates will be obtained. It should be noted that an age-estimate of the expanded secondary craters in Arcadia Planitia was previously performed based on counts of the superposed craters on the source primary craters and their ejecta. This estimate, on the order of tens of millions of years old, was interpreted to be a lower limit on the age of the ice, since it is expected that widespread removal of the ice mantle would also degrade the expanded crater morphologies [20]. However, this age is anomalously higher than the 0.5-2.1 Myr age predicted for the mantle deposits in the northern plains of Mars [7]; additional age-dating of the mantle surface adjacent to thermokarstically-expanded secondary crater clusters may help resolve this difference.

Discussion: Age estimates of a test swath in the Utopia Planitia region were performed as a proof-of-concept. The swath is ~40 km wide; the geographic location is delineated in Figure 1, and the mapped mantled terrain and age-dating results are shown in Figure 2. This analysis revealed a mantle age estimate of ~1.1 ± 0.3 Myr, which is roughly consistent with the expectation that the mantle deposit is fairly young, and likely associated with geologically-recent climate changes [7]. However, work is ongoing to refine this age estimates over a larger mantled area within Utopia Planitia. In addition, continued work in Arcadia Planitia may help account for the age of the mantle deposit and perhaps place it in context with the estimated age of regional thermokarstic modification.. The overall aim of this analysis is to better understand the history of these shallow ice deposits, particularly as it pertains to the timing of ice deposition relative to subsequent thermokarstic degradation in the context of orbital-induced climate variability.

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