AGE-DATING OF MID-LATITUDE MARTIAN THERMOKARST AND MANTLE DEPOSITS: A PRELIMINARY ASSESSMENT. D. Viola, NASA Ames Research Center, Moffett Field, CA.

Introduction: Outside of the Mars polar caps, water ice is abundant in the shallow subsurface of the planet's mid-latitude plains [e.g., 1-6], and the deposition and removal of this ice mantle over time are thought to be closely linked to climate [7], particularly to the planet's obliquity cycles [8-9].

The degradation of mid-latitude ice has been inferred from the presence of dissected mantle [10] and thermokarst-like depressions [e.g., 11-12]. On Earth, "thermokarst" refers to landforms that form as a result of the melting of ground ice in excess of the available pore space [13]. On Mars, mechanisms invoking thaw processes [14-15] or sublimation alone [16] have been proposed. Under current climatic conditions, however, it is very difficult to theoretically produce significant amounts of liquid water to produce thermokarst akin to that of Earth. It is unclear whether thermokarstic degradation is an ongoing process under the present climate (due to the slow rate of sublimation-modification and the short time over which high-resolution imagery is available), but crater age-dating of the thermokarstic depressions and the intact mantle that surrounds them can help to provide some temporal constraints on mantle deposition and thermokarstic modification.

Scalloped depressions are a common thermokarstic morphology found on Mars. These features are topographic depressions with steep pole-facing scarps and a shallow equator-facing slopes, with arcuate edges that sometimes contain one or more parallel ridges downslope of the outermost pole-facing scarp face. They typically range in diameter from a few hundred meters to ~3 km and sometimes coalesce into larger assemblages [12, 17-18]. Another feature interpreted as thermokarst in origin are "expanded" craters, with central crater bowls, a shallow apron to the surrounding surface, and a lack of crater rims such that the diameter of the craters appear to have widened over time, attributed to the removal of shallow excess ice and collapse of crater rims/dry dust overlying ice into the crater depression [16, 19].

Methods: Crater age-dating is a common method used to approximate how long a planetary surface has been exposed and accumulating impact craters. Absolute age-dating requires some assumptions about the crater production rate; lunar crater distributions can be linked directly to radiometric dating of returned samples [e,g., 20], and those production functions have been extrapolated to planets like Mars [21-22]. While there are some challenges to using this method for very small and/or very young surfaces [23], it can nevertheless provide valuable constraints on the timing of geologic processes. Key considerations include ensuring that craters are only counted within a single geologic unit and not spanning different surface types that could have formed at different times.

To help accomplish separation among geologic sub-units, terrain mapping will be performed to delineate the intact mantle from the regions that have been thermokarstically-altered. Superposed craters will be subdivided between these types of units to provide estimates of the surface age dates; while the subunits of intact mantle are geographically separate in some cases, they bear similar characteristics and are interpreted as remnants of the same topography-blanketing unit. Thus, the total number of superposed craters per total mantled area will be considered in obtaining age estimates. All mapping is performed using images from the Context Camera on the Mars Reconnaissance Orbiter, as this data set has near-global geographic coverage at fairly-high resolution (6 m/pixel) [24].

Study Areas: This study will focus on the northern mid-latitudes of Mars, primarily within Utopia Planitia, as well as a small study area in Arcadia Planitia (Figure 1). Utopia Planitia contains abundant scalloped depressions [e.g., 17], and it is thought that these scallops are young based on a qualitative observation that there are few impact craters observed in the regions where they are found. However, little quantitative work has been done in this regard. A region of Utopia Planitia (~60,000 sq. km) has been identified for preliminary mapping work (Figure 1); the preliminary results from a test swath within this region are presented here.

In addition, a small section of Arcadia Planitia will be similarly analyzed. Arcadia Planitia contains thermokarstically-expanded secondary craters [19], and a dense region of thermokarstic alteration has been identified for more focused surface crater counts. The age of the secondary craters was previously approximated using crater counts superposed on the source primary craters and their ejecta, where they were found to be on the order of tens of millions of years old. This estimate is anomalously-high for the anticipated age of mantle deposits throughout the northern plains of Mars of 0.5-2.1 Myr [7]; additional age-dating of the mantle surface immediately sur-

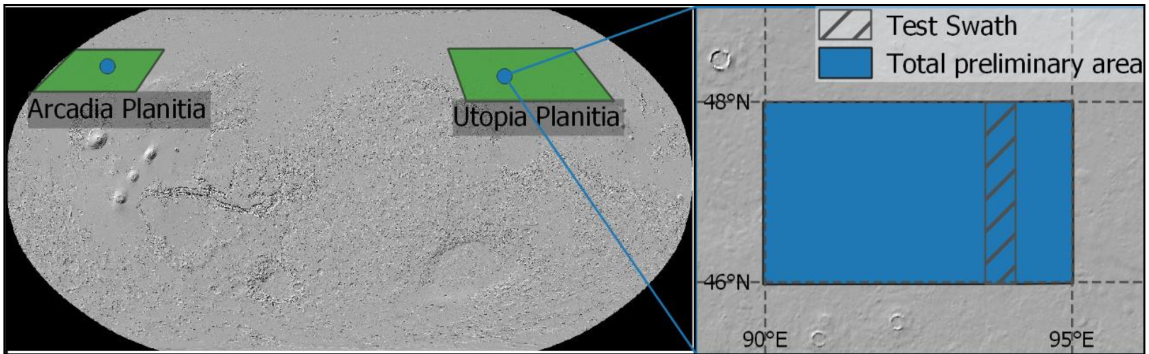

Figure 1: (Left) Global map of Mars showing areas of interest; blue points represent specific study area locations. (Right) Utopia Planitia study area; striped region represents a preliminary test-swath (results shown in Figure 2).

rounding the thermokarstically-expanded secondary crater clusters may help to resolve this difference.

Discussion: Age estimates of an early analysis of a test swath in the Utopia Planitia region were performed. The swath is ~40 km wide; geographic location is delineated in Figure 1, and the mapped terrains and age-dating results are shown in Figure 2. This analysis revealed age estimates for the mantle of ~1.1 ± 0.3 Myr, whereas the thermokarstically-degraded regions had an age estimate of 280 ± 100 kyr (Figure 2). These results are roughly consistent with the expectation that both the mantle and thermokarstic depressions are fairly young, and likely associated with geologically-recent climate changes. However, work is ongoing to obtain age estimates over a larger area, and these approximations are subject to change with the mapping of larger areas. In addition, continued work in Arcadia Planitia may help account for the age of the mantle deposit and the timing of thermokarstic alteration. The overall aim of this analysis is to better understand the history and of these non-polar shallow ice deposits, particularly as it pertains to the timing of both ice deposition and thermokarstic degradation, which are closely related the planet's climate history.

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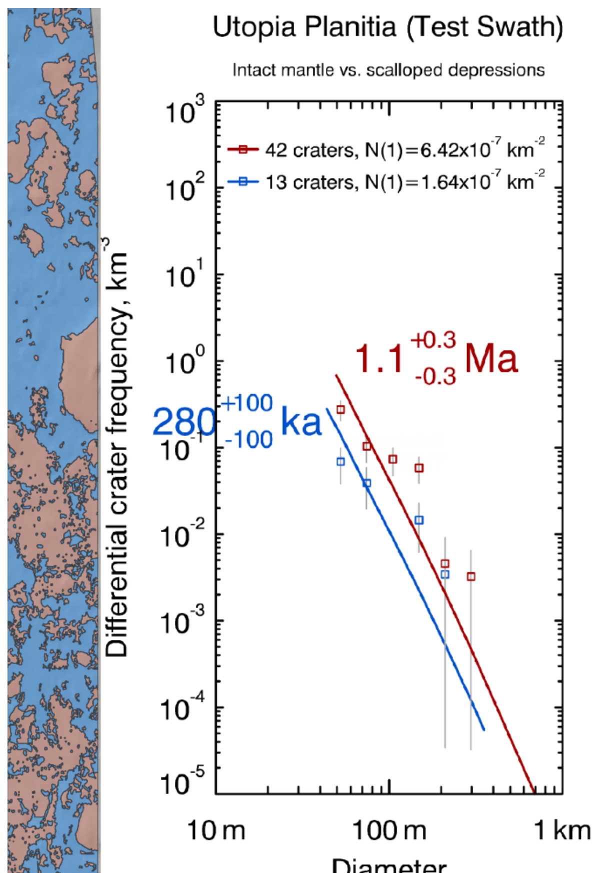

Figure 2: (Left) Mapped terrains in the Utopia Planitia test swath (area shown in Figure 1), where red is intact mantle and blue is scalloped terrain. (Right) Age-dating results for the two terrain types. Red corresponds to the crater distribution superposed on the intact mantle, and blue represent those found within scalloped depressions.