CRATERS AS AN INDICATOR OF MARTIAN REGOLITH THICKNESS. M. S. Gilmore, Jet Propulsion Laboratory, MS 183-335, 4800 Oak Grove Drive, Pasadena, CA 91109, msg@pop.jpl.nasa.gov.

Introduction: Two craters (D ~ 900 m) found in MOC images of Xanthe Terra have concentric terraced morphologies, where one crater lies within a second, larger crater. This type of morphology has been documented on the Moon [1,2,3,4] and attributed to an impact into fragmental material overlying a more competent substrate. These craters offer a mechanism by which to estimate thickness of unconsolidated surface material over large areas on Mars. Such measurements may constrain deflation rates and volume estimates of hydrologic reservoirs on Mars and yield information on the strength of the local bedrock.

Observations: Two craters have been observed in MOC image 40203 located approximately 13.2°N, 45.2°. The craters lie within the Hesperian Ridged Plains unit [5], approximately 175 km NE of the highland lowland boundary in this region. In Viking images, the plains here are dominated by mottled units interpreted to be lava flows, and contain knobs, mesas, and NNW-trending ridges. The MOC image confirms the presence of these features (Figure 1). Knobs and mesas are surrounded by units of variable albedo; many of these units display flow fronts and contacts with other units suggesting these are lava flows. Lava flow units can be further defined by and relatively uniform albedo and discernable crater density. Wrinkle ridges up to 30 meters across deform the plains units and may extend for several km.

Two adjoining craters, each ~900 m in diameter penetrate a mesa unit that lies above the plains in this area (Figure 1). The sunward-facing slope of the mesa is brighter than both the underlying plains and the mesa surface (similar albedo). Irregular bright albedo patterns on the mesa top suggest that the surface material is thin and is eroding away, yielding a view into underlying material. This type of surface is seem throughout the surrounding plains, suggesting the dark plains overlie lighter material, or the plains collect lighter material in some areas (may reflect surface roughness variations).

The craters are characterized by a terraced interior, where a crater lies concentrically within another crater. These concentric craters [1,2,3] and may result from an impact into unconsolidated material (the mesa) overlying a more competent layer (the plains). This situation was modeled in the laboratory [1,2] to explain similar features on the Moon. These experiments yield threshold values for $R = D/z$, where D is the crater diameter and z in the depth of the sand layer. R values for the change in geometry from bowl shaped to flat bottomed (R=3.8-4.2) and flat-bottomed to concentric (R=8-10) were found to vary only with strength of the substrate, where the size of the interior crater for concentric morphologies increases with decreasing substrate strength [2]. This supports the hypothesis that a portion of the energy of the impact is used to break the bonds in the underlying competent substrate and less mass is excavated from the inner crater.

Laboratory experiments [2] further show that there is no systematic dependence of R on impactor velocity or strength, impact angle, or gravity. Therefore we may extend threshold values of R calculated for the Moon to the martian craters in Figure 1 (D ~ 65 m) yield a range of regolith thickness of 90-113 meters. These values represent a maximum layer thickness. Minimum layer thickness can be determined by observing fresh, flat bottom craters in the same region or by photogrammetry. Shadow measurements of the eastern wall of the southernmost crater onto the terrace yield a wall height of 21 m; this underestimates the regolith thickness as the terrace surface is covered with ejecta from the interior crater which reduces the wall height. These numbers can be compared with <20 m regolith thickness reported for mare craters Moon [3].

Discussion: The Xanthe region, erosion and deflation expose the underlying layers making it relatively easy to identify the surface layer and substratum and interpret their origin. Concentric craters may prove valuable in the cratered highlands where underlying strata are not as well exposed. Within the highlands regolith thickness may be related to age of the formation of the substratum, proximity to impact crater ejecta, or fluvial deposition. Multiterraced craters may correlate with interbedded layers in the upper 100 meters of martian crust. The presence of brecciated regolith may be required for the formation of ground-ice sapping valleys on Mars [6] and thus positive correlation of regolith thickness with fluvial morphologies is predicted.

Is the competent layer permafrost? Minimum cryosphere depths are calculated to range from ~0.1 – 1.2 km depth for the mid to high latitudes [7]. Fresh, flat-floored craters that show evidence of sublimation or central pits (melted subsurface) may be present within < 1 km diameter craters in high latitudes.

The next phase of this study will utilize MOC data to investigate some of the above possibilities in order to constrain surface layer thickness and substratum characteristics in the southern highlands.

References: [1] Oberbeck V. R. and Quaide W. L. (1967) *JGR*, 72, 4697-4705. [2] Quaide V. R. and Oberbeck W. L. (1968) *JGR, 73,* 5247-5270. [3] Oberbeck V. R. and Quaide W. L. (1968) *Icarus 9*, 446-465. [4] Head J. W. (1976) *Proc. LPSC 7*, 2913-2929. [5] Scott D. H. and Carr M. H. (1978) *USGS Misc. Ser. Map I-1083*; Scott D. H. and Tanaka K. L. (1986) *ibid., I-1802-A*. [6] Lee P. et al. (1999) *LPSC XXX*, #2033. [7] Clifford S. M. (1993) *JGR, 98*, 10973-11016.

Figure 1. Portion of MOC image 40203. Image center ~13.25°N, 45.18°, resolution 13.9 m/pixel. Image is 6.6 kilometers across. Two craters, each ~900 meters in diameter, show an inner terrace concentric with outer crater rim. P refers to the plains units (assumed substratum) and M to the mesa unit at this location.