

Prospecting for Martian Ice. S.A. McBride¹, C.C. Allen², M.S. Bell³, ¹Cornell University, Ithaca, NY, ²NASA Johnson Space Center, Houston, TX, ³Lockheed Martin @ Johnson Space Center, Houston, TX.

Introduction: During high Martian obliquity, ice is stable to lower latitudes [1,2] than predicted by models of present conditions and observed by the Gamma Ray Spectrometer (~60°N) [3]. An ice-rich layer deposited at mid-latitudes could persist to the present day; ablation of the top 1 m of ice leaving a thin insulating cover could account for lack of its detection by GRS. The presence of an ice-layer in the mid-latitudes is suggested by a network of polygons, interpreted as ice-wedge cracks [4,5]. This study focuses on an exceptional concentration of polygons in Western Utopia (section of Casius quadrangle, roughly 40°-50°N, 255°-300°W) [6]. We attempt to determine the thickness and age of this ice layer through crater-polygons relations.

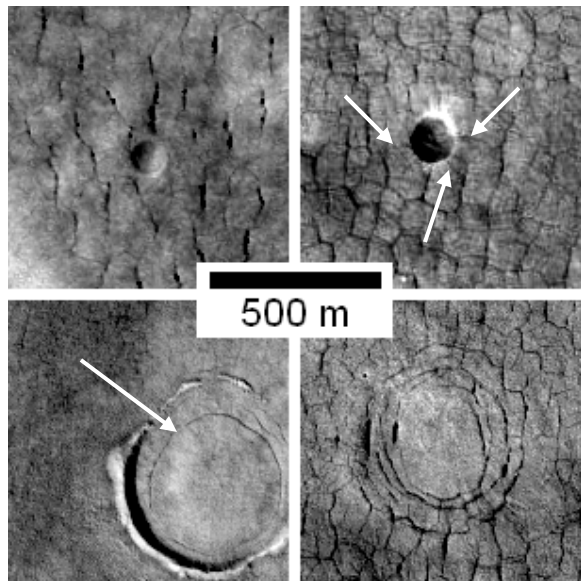


Figure 1 – Crater morphologies in relation to polygonal fractures as seen in MOC images (clockwise from top left): fresh (image R0301150); radial cracks (M0401631); concentric cracks (R0502250); inner wall cracks (R0501314).

Methods: Using a list of MOC frames showing polygons [7], we completed a survey of craters within 9120 km² of polygonal terrain in all narrow angle MOC images in the latitudes 30°-65°N released between 09/97 and 09/03 [8]. 72% of these polygons were in the Casius quadrangle. For craters with diameters greater than 100 m we recorded location, diameter, and crater morphology (Figure 1): fresh, radial cracks, concentric cracks, or inner wall cracks. Fresh craters appear younger than polygons as they are not cross-cut by any cracks. Radial cracks around

a crater are interpreted as cracks forming in relation to the free face of the inner crater wall. Concentric cracks are circular rings of cracks in an otherwise normal polygonal network. Inner wall cracks are similar to concentric except they form in craters with rims still protruding. The presence or absence of thermokarst features and the density of craters smaller than 100 m were also noted.

Thickness of the ice layer: Many craters are only visible as concentric cracks in an otherwise random polygon network. The pattern of ice-wedge cracking appears to be controlled by an underlying crater rim or fractures associated with cratering. There appears to be a diameter dependent boundary between such concentric cracks, and inner wall cracks forming around a still-protruding rim. Apparently craters up to a certain size have been buried by the ice rich layer, while larger craters have not. The largest buried crater has a diameter of 1.12 km, while the smallest partially buried crater with a protruding rim has a diameter of 0.46 km. The diameter of the smallest craters with protruding rims shows a slight increase with latitude (Figure 2).

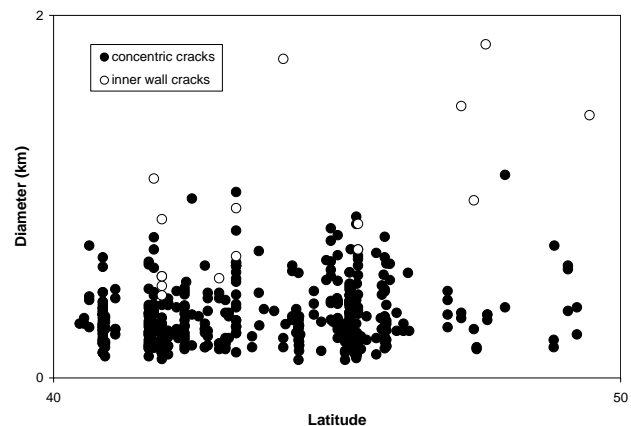


Figure 2 – Crater morphology by size and latitude showing diameter-dependent transition.

A sharp decline in the density of very small craters (< 100 m) northwards suggests they are being degraded or buried. Mantling has been suggested to have recently operated in the northern plains [1,9]. The diameter dependent morphology transition of craters supports this hypothesis, and provides a method of gauging the thickness of the mantle. As the crater may be a preferred site of deposition of ice and dust, the rim height rather than the depth is a better parameter to use for crater burial. Using the relation $h_{rim}=0.04D^{0.31}$ [10], the mantling ice is

calculated to be 31 to 41 m thick. As this expression for rim height is for all Martian craters, including partially buried ones, the calculated thickness represents a minimum value.

Age of the ice layer: 97% of craters observed in the Casius quadrangle predate polygon formation, suggesting a very young age for the ice. By adjusting the calibrated lunar crater flux for Martian gravity, orbit, and atmosphere, others have developed an absolute dating system for Mars. According to these crater density isochrons (Figure 3) [11], polygons were forming until between 0.5 and 10 Ma.

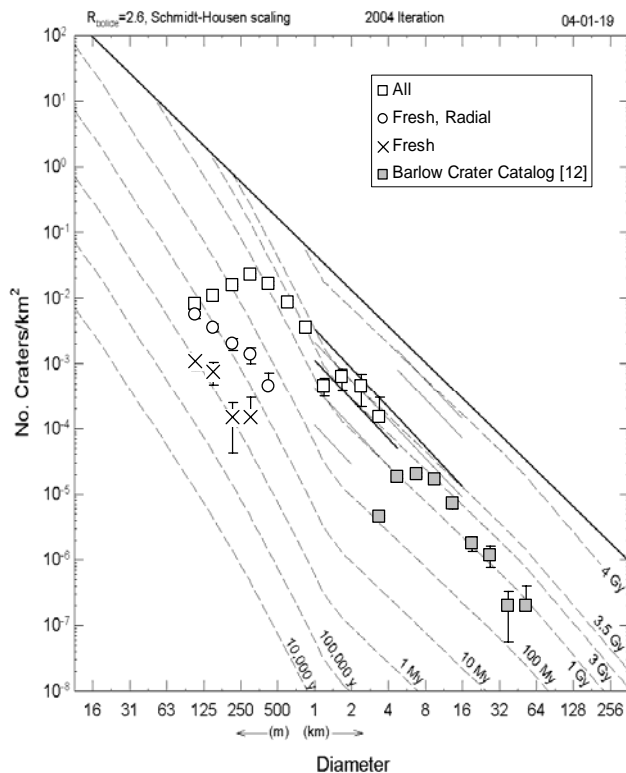


Figure 3 – Density distribution for craters associated with polygons in the Casius quadrangle, as well as all craters > 3 km [12]. Isochrons from [11].

Fresh and radially cracked crater abundances suggest that the mantling unit stopped forming at 5 to 50 Ma, older than the last high obliquity cycle. Mars has greater fluctuations of obliquity than the Earth, including regular oscillations as well as a generally higher level of obliquity before 5 Ma [13,14]. Isochrons [11] suggest the formation of the majority of the blanket before the drop to present obliquity ranges at 5 Ma, as in [2,14]. Perhaps mantling occurs in the high amplitude part of the obliquity oscillations, and was magnified before 5 Ma.

All craters, including those seen only as concentric rings of polygons, align well with a count done for larger craters ($D = 3\text{-}80$ km) [12] that gave a Hesperian-Amazonian age. However, densities decrease for craters smaller than 1 km, again suggesting a mantle burying craters up to this size.

Nature of the ice layer: The survey also revealed some related trends in ice-associated features. Most polygons north of 60°N are light relative to their surroundings, while most south of 60°N are dark. Thermokarst in the polygons is present mostly between 40°-50°N, mostly in the northern half of this range. Indicators of climate change include widening polygons, polygons on thermokarst, mantled thermokarst, and layered thermokarst scarps.

The polygons scattered across the rest of the northern plains differ considerably from the Casius concentration. The northern polygons are in general wider and less well defined. On average the crater distribution matches the Casius quadrangle; however, some areas have the appearance of being much older due to extensive cratering. The global diameter dependent transition from concentric to inner wall cracks matches well with the Casius quadrangle.

Conclusion: An ice rich layer approximately 40 m thick is revealed by the presence of recently active ice-wedge polygons in at least part of the Casius quadrangle, and possibly more extensively across the northern plains. Higher obliquity probably caused deposition of the mantle before 5 Ma; formation of polygons has continued until the present.

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