TOPOGRAPHY OF NORTHERN HEMISPHERE MARTIAN CENTRAL PIT CRATERS. H. M. Kagy[1] and N. G. Barlow[2], [1]4021 Horseshoe Drive, Cedar Falls, IA 50613, hmkagy@gmail.com; [2] Department of Physics and Astronomy, Northern Arizona University, NAU Box 6010, Flagstaff, AZ 86011-6010, Nadine.Barlow@nau.edu.

Introduction: Central pit craters are abundant on icy worlds but are lacking on the volatile-poor worlds of our solar system. These craters are thought to be an indicator of water ice as the central pit may be caused by a rapid vaporization process upon impact. Central pits in craters on icy moons such as Ganymede typically occur on updomed floors, likely caused by post-impact rebound of the ice-rich target. In this study, we use MOLA topography to determine if Martian northern hemisphere central pits also occur on updomed floors. The presence or absence of updomed floors in Martian central pit craters can help constrain the concentration of target ice in the location of these craters.

Central Pit Craters: Central pit craters are impact craters which include a central depression either in place of or on top of a central peak. The two main types of central pit craters on Mars are floor and summit pit craters [1]. The pits of floor pit craters lie on a relatively flat crater floor whereas summit pits top an obvious central peak.

Central pit craters are not found everywhere in the solar system. Central pit craters are only found on Mars and icy moons (there are possibly one or two terrestrial examples) and thus are thought to be indicative of subsurface ice targets. One common theory for their formation involves the physics of impact crater formation and is supported by recent computer simulations. In this model, the central pit results from rapid vaporization of the subsurface volatiles in an ice-rich target [2]. Hydrocode modeling indicates that impacts into ice-rich targets produces a zone of extremely high temperatures under the center of the transient crater, exactly where central pits occur [3]. Collapse of a central peak structure forming in a weak ice target has also been proposed to explain central pits [4], but this model clearly does not explain the Martian summit pit craters. Another theory suggests the impactors were high-velocity icy comets rather than asteroids [5]. However we would expect observations of central pit craters on the Moon and other volatile-poor worlds.

On Ganymede central pits typically occur on updomed crater floors [6]. Summit pit craters are extremely rare on Ganymede compared to Mars [7]. The updomed floor is likely the result of post-impact rebound of the icy target material. Icy targets have lower strength than rocky targets and thus viscous relaxation occurs on shorter time periods in icy materials. The amount of ice in the Martian crust is not well constrained at the depths excavated by the central pit craters. The presence or absence of updomed floors for Martian central pit craters can therefore provide us with some constraints on the amount of target ice at depths of a few kilometers.

Procedure: Barlow's *Catalog of Large Martian Impact Craters, version 2.0* [8] identifies 756 central pit craters in the northern hemisphere of Mars based on analysis of THEMIS daytime IR and visible imagery. Using the JMARS application [9], we determined the topographic variations across each central pit crater. Measurements were obtained along two profiles for each crater (one roughly east-west and the other approximately north-south) and the results averaged. Two sets of data were necessary due to depth uncertainties caused by floor deposits, collapse features, and dunes within the craters. Measurements were taken of the depth to the bottom of the central pit relative to the crater floor and relative to the surrounding surface. The base of the pit relative to the crater floor allowed us to classify the type of central pit: floor pits had the pit base below the crater floor while the base of summit pits was above the crater floor. Figures 1 and 2 show reprsentative profiles for summit pit and floor pit craters.

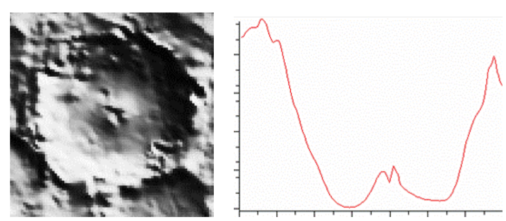

Figure 1: Example of a summit pit crater (left) and its topographic profile (right).

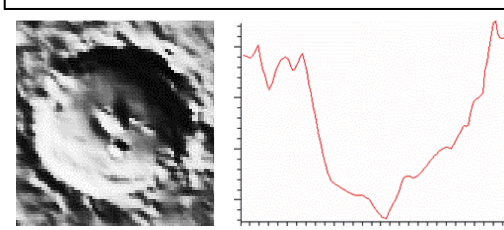

Figure 2: Example of a floor pit crater (left) and its topographic profile (right)

We compiled a database with information on crater diameter, floor depth, pit depth, and floor profile for each crater. Information about the shape of the crater floor allowed us to investigate whether the floors of central pit craters show any evidence of updoming which would suggest extremely high concentrations of ice at depths of a few kilometers.

Results and Implications: Domed craters were not equivocally identified in our analysis of northern hemisphere pit craters on Mars. This implies that high concentrations of subsurface ice are not present at depths of a few kilometers (the excavation depth of central pit craters). Ice/rock concentrations of ~16-20% have been suggested from studies of layered ejecta blankets [10, 11] and are consistent with these results

Figure 3 shows the distribution of floor (green) and summit (red) pits in the northern hemisphere. The low concentration of central pit craters in the Arabia Terra region is an artifact—analysis of craters in this region for the *Catalog of Large Martian Impact Craters, Version 2.0*, was not complete at the time of our study. The Tharsis region displays few craters due to its geologic youth from relatively recent volcanism in the region. Some clustering of central pit craters is suggested by Figure 3: Floor pits seem to be favored in the Tharsis and Elysium regions around the volcanoes and in the eastern part of Sytis Major. Summit pits are clustered along the hemispheric dichotomy. However, even within these clusters, craters of the other pit type are found—we see no locations where only one type of pit crater is found. Analysis of central pit craters in the southern hemisphere will allow us to determine if these trends continue. The results of the complete survey will allow us to better constrain the conditions under which central pit craters form.

Acknowledgements: HMK acknowledges the support of the NSF Research Experiences for Undergraduates program at Northern Arizona University in conducting this research (NSF award AST-0453611). NGB acknowledges support from NASA MFR Award #NNG05GM14G. Special thanks to JMARS, THEMIS, MOLA, ESRI ArcGIS, and Trent Hare of the USGS—Flagstaff.

References: [1] Barlow N. G. and Hillman E. (2006) *LPS XXXVII*, Abst.#1253. [2] Wood C. A. et al. (1978) *Proc. of 9th LPSC*, 3691-3709. [3] Pierazzo E. et al. (2005), *Large Meteorite Impacts III*, 443-457. [4] Greeley R. et al. (1982), in *Satellites of Jupiter*, Univ. AZ Press, 340-378. [5] Croft S. K. (1983) *JGR*, 88, B71-B89. [6] Schenk P. M. (1993), *JGR*, 98, 7475-7498. [7] Barlow N. G. (2007) *LPS XXXVIII*, 1242. [8] Barlow N. G. (2006) LPS XXXVII, Abstract #1337. [9] Gorelick N. S. et al. (2003), *LPS XXXIV*, Abstract #2057. [10] Woronow A. (1981), *Icarus*, *45*, 320-330. [11] Stewart S. T. et al. (2001) *LPS XXXII*, Abstract #2092.

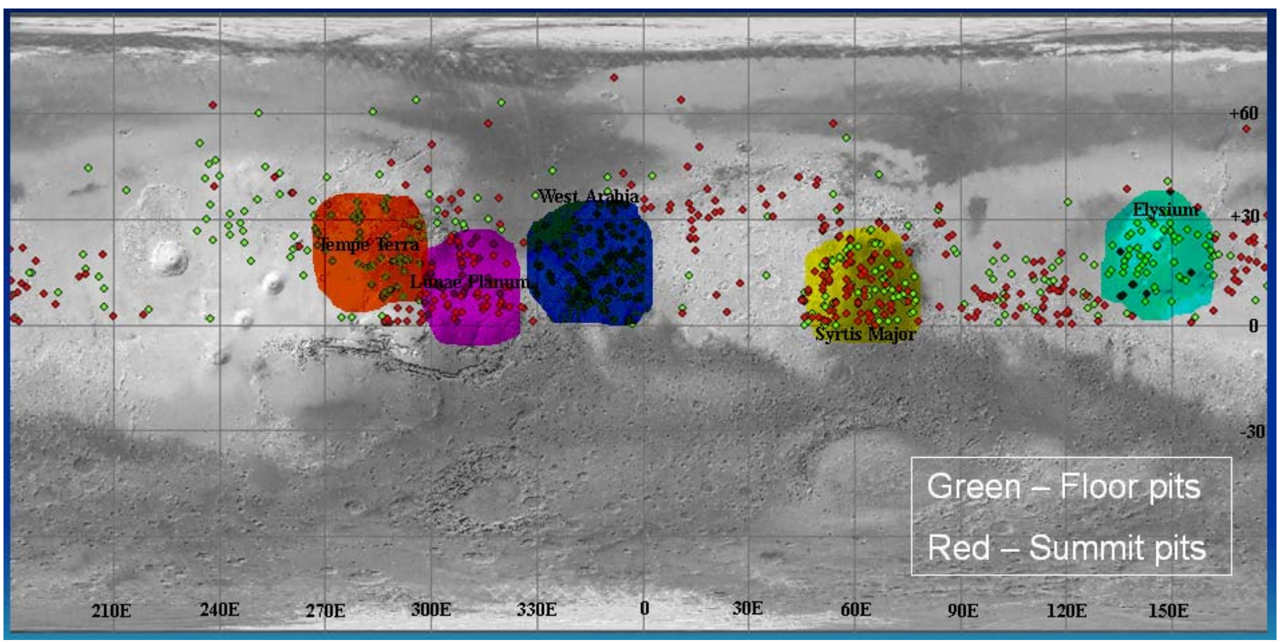

Figure 3: Floor versus summit pit distribution for the northern hemisphere of Mars. Highlighted areas are regions of suggested central pit concentrations.