A SURVEY OF MARTIAN CENTRAL PIT CRATERS—STATUS REPORT. N. G. Barlow, Dept. Physics and Astronomy, NAU Box 6010, Northern Arizona University, Flagstaff, AZ 86011-6010 Nadine.Barlow@nau.edu.

Introduction: Central pit craters are impact craters with depressions near the crater center and are common on Mars, Ganymede, and Callisto. Central pits in Martian impact craters occur directly on the crater floor ("floor pit") or atop a central peak ("summit pit"). Central pits are commonly believed to form by interaction with target volatiles during crater formation. This project is compiling a database of Martian central pit craters and analyzing their distributions across the planet in order to better understand the impactor and environmental factors which produce these features.

Martian Central Pit Crater Database: We utilize Mars Odyssey Thermal Emission Imaging System (THEMIS) daytime IR and VIS imagery to identify Martian central pit craters. Pits are classified as floor pits if the pit floor lies below the crater floor level, and as a summit pit if the pit floor lies above the crater floor (MOLA data are utilized if visual inspection cannot distinguish the classification) (Fig. 1). Latitude and longitude of the crater center, crater diameter, crater preservational state (0.0-7.0 scale, with 0.0 [1]), ejecta morphology [2], interior morphologies, pit diameter, and ratio of pit to crater diameter are determined for each central pit crater. The database currently contains 1307 central pit craters: 899 in the northern hemisphere and 408 in the 0°-30°S 180°-315°E region in the southern hemisphere. Out of the 1307 craters, 785 are floor pits and 522 are summit pits.

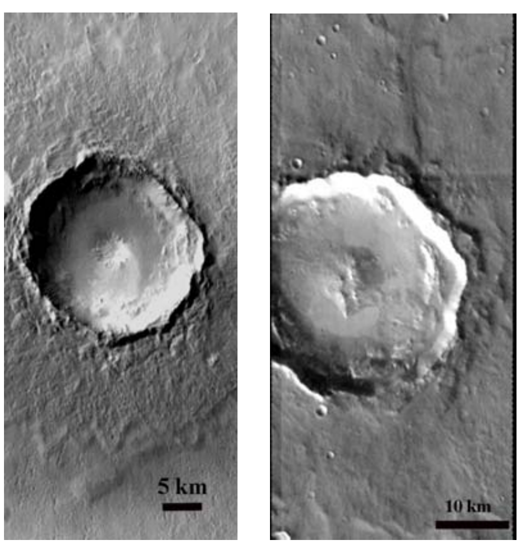

Figure 1: Examples of floor pit (left) and summit pit (right) craters. (THEMIS images I11284045 (left) and I24502007 (right))

General Analysis: Floor and summit pit craters occur in similar diameter ranges (Fig. 2). Craters containing floor pits range from 5.0 to 114.0 km diameter with a median at 14.7 km. Diameters of summit pit craters range from 5.1 to 125.4 km; the median value is the same as for floor pit craters. Although the data are currently limited for the southern hemisphere, northern hemisphere central pit craters have a larger median diameter (15.2 km for floor pit craters; 15.7 km for summit pit craters) than southern hemisphere central pit craters (12.4 km for floor pit craters and 13.0 km for summit pit craters). We will see if this trend continues once the survey of the southern hemisphere is completed.

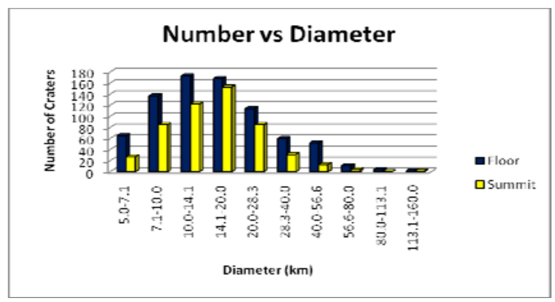

Figure 2: Number of floor and summit pit craters vs crater diameter. Median diameter for both floor and summit pits is 14.7 km.

Floor pit and summit pit craters are found in similar locations across the planet. However, subdividing the planet into 10° latitude by 10° longitude blocks and normalizing the number of central pit craters to the total number of craters in each block reveals some concentrations. Floor pit craters in the north are heavily concentrated in Tharsis, Lunae Planum, Syrtis Major and Elysium (Fig. 3). Northern hemisphere summit pit craters have highest concentrations in the highlands terrain of Arabia Terra (Fig. 4).

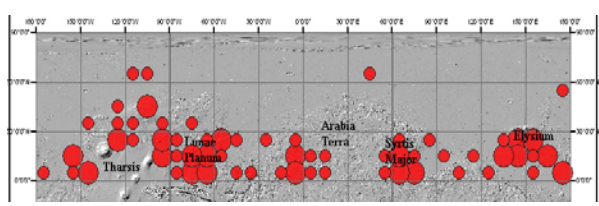

Figure 3: Normalized distribution (relative to total number of craters) of floor pit craters in the northern hemisphere of Mars. Larger circles represent >20% concentration of floor pits in a particular 10° latitude x 10° longitude block. Smaller circles represent 10-20% floor pit concentration.

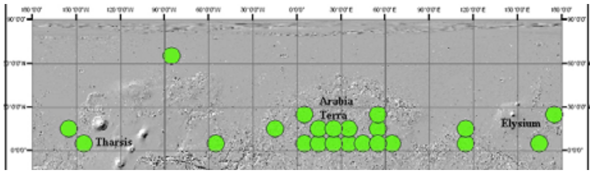

Figure 4: Normalized distribution (relative to total number of craters) of summit pit craters in the Martian northern hemisphere. Circles represent 10-20% concentration of summit pits in a particular 10° latitude x 10° longitude block.

The regional concentrations in Fig. 3 suggest that floor pits may preferentially form on volcanic plains. To test this, we reclassified Tanaka et al.'s [3] geologic units into volcanic, partially volcanic, and non-volcanic units, based on unit description. We overlaid the floor pit crater concentrations in the northern hemisphere onto these generalized geologic units using ArcGIS. Highest concentrations of floor pit craters occur in volcanic or partially volcanic units. This observation suggests that target strength and/or layering is important in the formation of floor pit craters on Mars.

Summit pit craters are, not surprisingly, found in the same areas of the planet as central peaks. A similar normalized analysis of central peak craters in the northern hemisphere finds a high concentration within Arabia Terra (Fig. 5). Thus the process producing regular central peaks and peaks containing summit pits is likely similar.

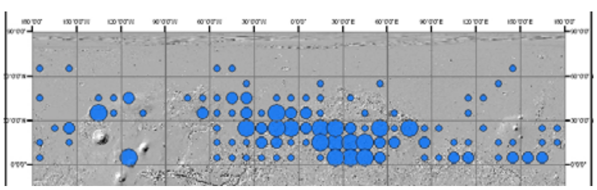

Figure 5: Normalized distribution (relative to total number of craters) of central peak craters in the Martian northern hemisphere. Small circles represent 10-20% concentrations of central peak craters in a particular 10° latitude x 10° longitude block. Medium craters are 20-30% concentrations and large circles are >30% concentration.

The ratio of pit (D_p) to crater (D_c) diameter may provide information about the amount of target ice available when the pit formed. D_p/D_c varies from 0.02-0.48 for floor pit craters and 0.02-0.29 for summit pit craters. Median D_p/D_c for floor pits is 0.16 compared to 0.12 for summit pits. Thus floor pits tend to be larger relative to their parent crater than summit pits. A companion study of central pit craters on Ganymede found that D_p/D_c is greater for Ganymede floor pit craters than for their Martian counterparts, consistent with higher ice concentrations on the icy moon [4]. No statistically significant variation is seen among D_p/D_c values for summit pit craters in the northern versus southern hemispheres (median D_p/D_c is 0.12 in the north and 0.11 in the south). Floor pits in the northern hemisphere appear to be slightly smaller than their counterparts in the south (median D_p/D_c = 0.15 in the north and 0.17 in the south), but the southern hemisphere survey needs to be completed to determine if this trend is statistically significant.

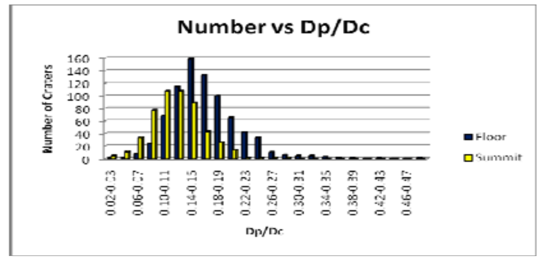

Figure 6: Number of floor and summit pit craters as a function of the ratio of the pit diameter (D_p) to the crater diameter (D_c). Floor pits are typically larger relative to their parent crater than summit pits.

Implications for Formation Models: A number of formation models have been proposed for central pit craters, including collapse of a central peak [5], vaporization and explosive release of subsurface volatiles [6], precursor stage to upwelling of a subsurface diapir [7], coalescence of pits produced by interaction of impact melt and target volatiles [8], and melting of target ice during crater formation and subsequent drainage of this melt into underlying fractures [9]. The melt-drainage model is the only one which can explain formation of both floor and summit pits and has numerical modeling support for formation of central pits on icy bodies [10, 11]. Modeling results are consistent with the observed central pit crater diameters, distributions, and D_p/D_c values for Ganymede central pits. Lower ice concentrations on Mars can explain the slight differences between central pit characteristics on the two bodies. Modeling also indicates that impact velocity plays a role in the production of central pits, with higher amounts of melt being produced by higher velocity impacts. This can help explain why a central pit crater can lie next to a crater of similar size and age but lacking a central pit.

References: [1] Barlow N.G. (2004) *GRL 31*, L05703. [2] Barlow N.G. et al. (2000) *JGR 105*, 26733-26738. [3] Tanaka K.L. et al. (1988) *PLPSC 18*, 665-678. [4] Alzate N. and Barlow N.G. (2010), submitted to *Icarus*. [5] Passey Q.R. and Shoemaker E.M. (1982) in *Satellites of Jupiter*, UA Press, 379-434. [6] Wood C.A. et al. (1978) *PLPSC 9*, 3691-3709. [7] Schenk P.M. (1993) *JGR 98*, 7475-7498. [8] Tornabene L.L. et al. (2007), *LPS XXXVIII*, Abs. #2215. [9] Croft S.M. (1981) *LPS XII*, 196-198. [10] Bray V.J. (2009), PhD thesis, Imperial College London. [11] Senft L.E. and Stewart S. T. (2010) submitted to *Icarus*.