DISTRIBUTIONS AND CHARACTERISTICS OF MARTIAN CENTRAL PIT CRATERS. N. G. Barlow and E. Hillman, Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011-6010; Nadine.Barlow@nau.edu; eah42@dana.ucc.nau.edu.

Introduction: Impact craters containing central pits are rare on dry bodies like the Moon but common on Mars and the icy moons of the outer solar system. Impact into and vaporization of subsurface volatiles is the probable cause of central pit formation [1, 2]. Viking-based studies of central pit craters on Mars found regional distributions of these craters, with an apparent preference for the outer rings of multiring basins [3]. However, image resolution hampered a complete analysis of central pit craters, particularly those at the smaller diameter range. Our current study utilizes THEMIS visible (VIS) and daytime infrared (IR) imagery to obtain a more complete survey of the distribution and characteristics of these unusual landform.

Methodology: The 18 m/pixel resolution of THEMIS VIS greatly surpasses the ~40-100 m/pixel resolution of the Viking Orbiters, providing more detailed views of martian impact craters. However, THEMIS VIS is limited in its spatial coverage. THEMIS daytime IR, while lower in resolution (~100 m/pixel), covers much of the planet's surface. It also often provides clearer imagery than visible images in the presence of the prevalent atmospheric hazes. This is particularly the case for the higher latitudes, which were often plagued with clouds or thick hazes during the Viking missions and where few central pit craters were detected in the earlier study. Thus, the primary dataset for this analysis is THEMIS daytime IR with THEMIS VIS being used when available.

We are perusing each THEMIS image frame in order of release date in search of central pit craters. When such a crater is identified, the latitude and longitude of its center is noted, its diameter is measured, the central pit's diameter is measured, the crater's preservational classification is determined [4], and its ejecta blanket, if present, is classified using the system described in [5]. Central pits are classified as floor pits if they occur on the crater floor (Figure 1) and summit pits if they occur on a central rise or central peak (Figure 2).

Preliminary Results: To date, we have identified approximately 1500 central pit craters on Mars, many of which where not detected in the previous Viking-based analysis. Floor pits are approximately twice as common as summit pits (68% vs 32%). Some pits are rimless while others display a slightly raised rim.

Diameter: Summit pit craters range in diameter from 7 to 40 km while those displaying a floor pit range from 6 to 57 km in diameter. The range of pit diameters is similar for both summit pits and floor pits: summit pit diameters range between 0.6 and 6.4 km while floor pit diameters lie between 0.7 and 7.0 km. However, the median summit pit diameter is 1.7 versus 2.2 for floor pits, indicating that on average summit pits tend to be smaller than floor pits.

The ratio of the pit diameter to the crater diameter confirms that summit pits tend to be smaller than floor pits independent of the size of the parent crater. D_{pit}/D_{crater} ranges between 0.05 and 0.19 for summit pits, with a median of 0.12. For floor pits, D_{pit}/D_{crater} ranges between 0.07 and 0.28, with a median of 0.15.

Morphology: Central pits are seen in craters ranging from fresh craters with well-preserved ejecta blankets to highly degraded craters. The classification system used here is described in [4] and assigns each crater a preservational value ranging from 0.0 ("ghost" crater) to 7.0 (extremely pristine). Both floor pit and summit pit craters in this analysis range in preservational age from 2.0 to 7.0. Not surprisingly those craters which have suffered large amounts of interior degradation/modification seldom show central pits. This is particularly obvious in the mid-latitude zones where terrain softening is seen—the only central pit craters seen in these regions are typically of preservation class 4.0 and higher (i.e., younger).

As shown in Figure 3, the majority of central pit craters (69% of floor pit and 83% of summit pit craters) are fresh enough to still display a distinguishable ejecta morphology. We also confirm our earlier report of central pit craters often showing a multiple layer ejecta morphology [6]. It is possible that this is an observational effect—the multiple layer ejecta morphology tends to be found around larger craters [7, 8], precisely those craters in which the central pit is most obvious in this visual survey. We have tested this idea by comparing 18 m/pixel VIS images of craters with their corresponding 100 m/pixel daytime IR images. In only a few cases are central pits visible in VIS and not in IR. While the HiRise camera on the Mars Reconnaissance Orbiter will allow us to test this observation more rigorously, we believe that our results are not strongly affected by resolution and that the correlation of central pits with craters displaying a multiple layer ejecta morphology is a solid result.

Geographic Distribution: While this project is still in its early stages and the entire martian surface has not yet been surveyed, we are already seeing evidence of regional variations in the distribution of central pit craters. We have surveyed THEMIS images within the latitude range 55°N to 70°S and find both floor pit and summit pit craters across this entire region. This is in contrast to the earlier Viking-based study where clouds and resolution effects prevented the detection of central pit craters at the higher latitudes. While central pit craters appear to be fairly evenly distributed across all longitude zones within this latitude range, we are seeing enhanced concentrations of central pits near Valles Marineris and in the Arabia Terra, Terra Cimmeria, and Gusev Crater regions of the planet. This suggests that while conditions for central pit formation are present across the planet, some regions exhibit particularly favorable conditions for the formation of these features.

Discussion: Central pit craters have been proposed to result from the explosive release of vapor produced during impact into subsurface volatiles [1]. This scenario has gained recent support from numerical simulations of impacts into soil-ice mixed targets, which find that the central region of the transient crater experiences temperatures well above the vaporization point of water [2]. Thus, the general mechanism by which central pits form in impact craters is becoming better understood. However, two major questions remain for central pit craters on Mars: (1) Why do some craters display central pits while neighboring craters of similar size and preservational state do not; and (2) why do some craters display floor pits while other exhibit summit pits? Our current study aims to determine the characteristics and distributions of central pit craters on Mars in order to better understand the conditions which lead to their formation. This study is complemented by a companion study of the distribution and characteristics of central pit craters on icy Ganymede [9]. Our current results suggest that some regions of Mars present more favorable conditions for central pit formation than others and that the conditions favorable for central pit formation also tend to favor formation of the multiple layer ejecta morphology. This suggests that variations in the concentrations or perhaps the physical state of subsurface volatiles combined with impact energy may dictate whether an impact crater forms a central pit.

References: [1] Wood C. A et al. (1978) *PLPSC 9th*, 3691-3709. [2] Pierazzo E. et al. (2005) *Large Meteorite Impacts III, GSA SP 384*, 443-457. [3] Barlow N. G. and Bradley T. L. (1990) *Icarus, 87*, 156-179. [4] Barlow N. G. (2004) *GRL, 31*, doi: 10.1029/2003GL019075. [5] Barlow N. G. et al. (2000) *JGR, 105*, 26733-26738. [6] Hillman E. and Barlow N. G. (2005) *LPS XXXVI*, Abstract #1418. [7] Barlow N. G. and Perez C. B. (2003) *JGR, 108*, doi: 10.1029/2002JE002036. [8] Barlow N. G.(2005) *LPS XXXVI*, Abstract #1415. [9] Klaybor K. and Barlow N. G. (2006) *LPS XXXVII*, this volume.

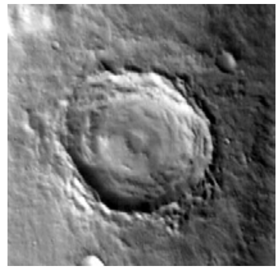

Figure 1: This 17.4-km-diameter crater contains a 2.8-km-diameter floor pit. Crater is located at 11.84°N 356.96°E. (THEMIS image I08526015)

Figure 2: Summit pit crater, located at 6°N 304°E. Crater is 25 km in diameter and exhibits a multiple layer ejecta morphology. (THEMIS image I03218002)

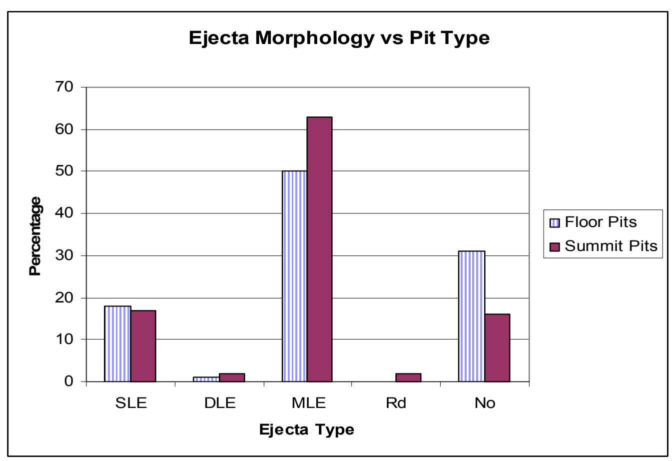

Figure 3: Graph showing the percentage of pit craters displaying a particular ejecta. SLE = single layer ejecta, DLE = double layer ejecta, MLE = multiple layer ejecta, Rd = radial ejecta, and No = no ejecta present.