Preliminary Thermal Investigation of Fresh-looking Pit Craters (FLPCs) E.M. Maclennan[1,2], G.E. Cushing[1] and T.N. Titus[1]. [1]U.S. Geological Survey, 2255 N. Gemini Dr. Flagstaff, AZ 86001, [2]Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86001.

Introduction: Fresh-Looking Pit Craters (FLPCs) are circular collapse features with vertical or overhanging interior walls and depth/diameter ratios usually > 0.5 [1]. Currently, 88 of these features have been observed thus far using the Mars Odyssey Thermal Emission Imaging System (THEMIS) [2]. Some FLPCs, if indeed similar to terrestrial analogs [3], may contain entrances into substantial void spaces beneath the surface, and here we begin an investigation into whether observed thermal signatures may reveal the presence of such caves. In THEMIS thermal-infrared (TIR) observations, FLPCs exhibit strikingly different temperature variations from both surrounding terrains, and from common-type (bowl-shaped) pit craters [1] (Figure 1). Comparable Lunar structures have also been discovered [4], and results from this investigation may help determine whether caves exist in those pits as well.

The majority of currently identified FLPCs are concentrated in the Tharsis region, and most of these are associated with Arsia Mons, a massive shield volcano where distal flows extend to more than 1000 km from the central caldera [2].

Data: Pit-crater diameters are derived using data from THEMIS, and from the Mars Reconnaissance Orbiter's Context Camera (CTX) and High-Resolution Imaging Science Experiment (HiRISE). Floor and surface temperatures are calculated using TIR Band-9 (~12.6 μm) images that have been orthorectified and mapped to Simple Cylindrical projections. TIR's native resolution of ~100 m/pixel is reprojected to 18 m/pixel (using nearest-neighbor interpolation) in order to 'super-register' TIR with visible-wavelength observations. FLPCs with diameters <100 m are excluded because they are too small to register in TIR data. The remaining larger pits are still only 2-3 times larger than TIR pixels, so a large amount of sub-pixel mixing is expected and should be accounted for (next section). We use only predawn TIR data in this preliminary investigation (~0300–0500 hr) because this is when thermal contrast with the surface is highest and the level of sub-pixel mixing can be most easily constrained.

Process: *Measuring Pit Size:* We examine all available images of each FLPC, and use that with finest resolution to determine its respective diameter (D) by counting pixels across the widest point. FLPC depth (d) is calculated by dividing the interior shadow length by the tangent of the observed incidence angle. Only minimum estimates of depth can be calculated if the FLPC interior is completely in shadow; in such cases, minimum depth is calculated using the smallest observed incidence angle (to provide greatest minimum depth).

Calculate Floor and Surface Temperatures: The pixel-counting technique provides ground truth for our routine to fit ellipses to FLPCs in THEMIS VIS observations. We produce best-fit ellipses using the downhill-simplex method of function minimization developed by [5] (Figure 2, left). To determine subpixel mixing in the TIR data, we use the same method by [5] to incrementally shift the TIR image across the VIS-based ellipse until the best fit is obtained (Figure 2, right). With TIR data registered to the best-fit ellipse, the degree of subpixel mixing is determined at each point according to both spatial and radiance differences between the floor and surface median.

This technique is in its first stage of development and we make several idealized assumptions at this time (e.g., that FLPC floors are flat, smooth and thermally homogeneous, and that vertical interior walls make no thermal contribution).

Results: FLPC diameters ranged from ~12 m to ~420 m in 88 FLPCs. Depths were calculated to range from ~7 m to >245 m. Floor/surface temperature differences were generally in 10-30 K range but could be as high as >50 K and as low as <6 K. Although further study is required, we are encouraged by our results. The temperature-difference vs. L_s plots in Figure 3 shows a dynamic range of behaviors for FLPCs around Arsia Mons (some of which may contain cave entrances), while thermal behaviors of 3 'pseudo FLPCs' in Tractus Fossae (no caves) are much more consistent.

Groupings in Figure 4 indicate some correlation between FLPC sizes and locations. Pits on the northern slopes of Arsia Mons tend to have the greater d/D ratios, and temperature differences are typically greatest when the d/D values are greater than ~0.7.

Conclusion: In our mission to thermally identify caves within FLPCs, we are highly encouraged by these preliminary results. Differences in thermal trends between FLPCs may indicate that some are strongly influenced by subsurface conditions. More FLPC thermal data, both during the nighttime and daytime, need to be acquired and examined in order to learn more. The next stage of this investigation is to compare the results determined here with those produced by numerical thermal-diffusion models.

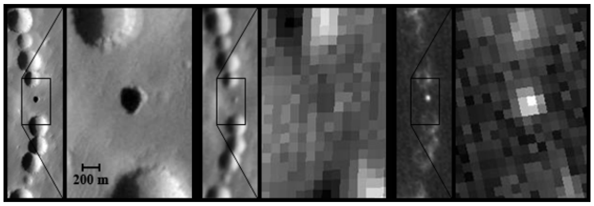

Figure 1: THEMIS VIS (left), afternoon TIR (center) and predawn TIR (right) observations of a Martian FLPC that formed within a chain of common pit craters. The FLPC is both thermally and morphologically distinct.

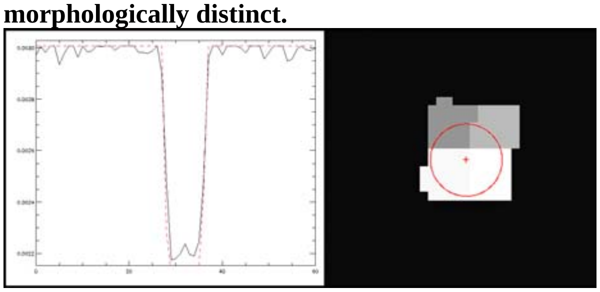

Figure 2: Left panel shows a result from our ellipse-fitting routine. Right panel shows the best-fit ellipse registered to TIR data with sub-pixel mixing.

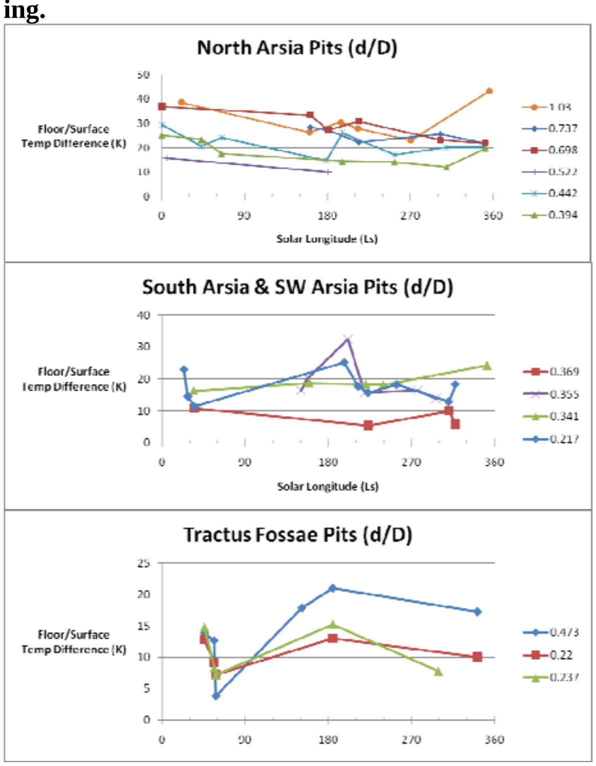

Figure 3: Plots of floor/surface temperature differences vs. season at different locations. Note the dynamic variability in the FLPCs near Arsia Mons (where some FLPCs are likely to contain cave entrances), while the Tractus Fossae pits (similar, but unlikely to contain cave entrances) show fairly consistent annual variations.

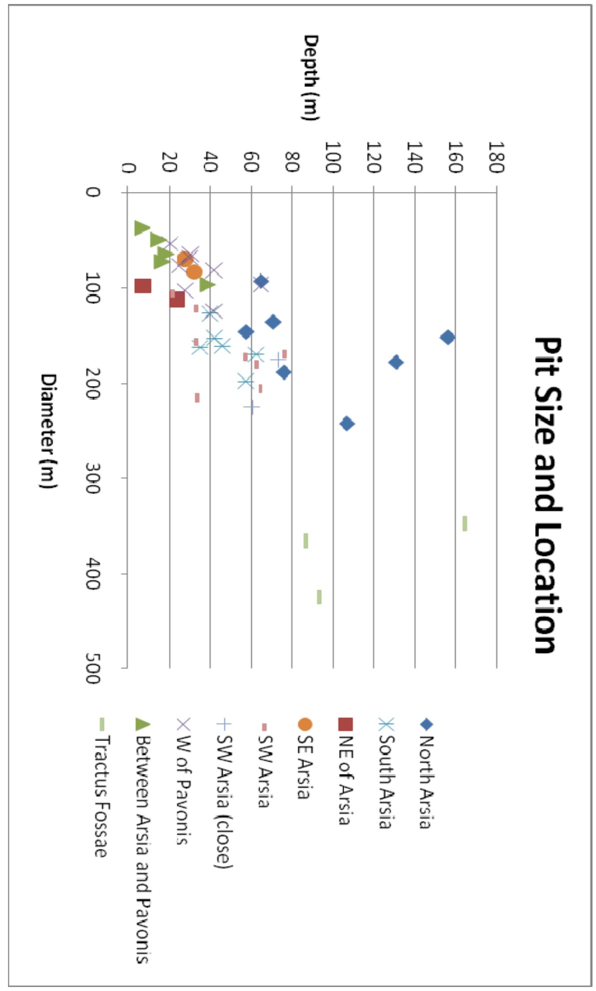

Figure 4: FLPC Diameter and Depth with the location indicated. This plot shows that pits found on the southern slopes of Arsia Mons typically have lower d/D values. In contrast, pits found on the northern slopes of Arsia Mons are deeper, which could indicate the presence of a cave entrance. It also seems that pits found in clusters, have similar size and/or d/D values.

References: [1] Cushing G.E. et al. (2007) *GRL*, 34, L17201. [2] Cushing, G.E. et al. (2010) *JGR*, in review. [3] Okubo C.H. and Martel S.J. (1998) *JVGR*, 86, 1-18. [4] Haruyama, J. et al. (2009), GRL, 36,21. [5] Nelder, J.A. and R. Meade (1965) *Comp. J.*, v.7.