Paleo-Lakes in Central Pits, Mars: an Update. S. E. Peel[1] and D. M. Burr[1], [1]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville (speel1@vols.utk.edu).

Introduction: Central pit craters (CPCs) are a type of impact crater that contains a centrally located, approximately circular formed during crater emplacement [e.g., 1-3]. Previously, 96 floor-type central pit craters, in which the bottom of the central pit is topographically lower than the crater floor outside the pit, were found to contain valleys (Fig. 1; [4]). Of these 96 craters with valleys, 5 were found to have channels draining into them with higher discharge values than expected for later periods of Mars [4]. Additionally, calculations showed that under certain conditions, the central pits could have hosted lakes [4].

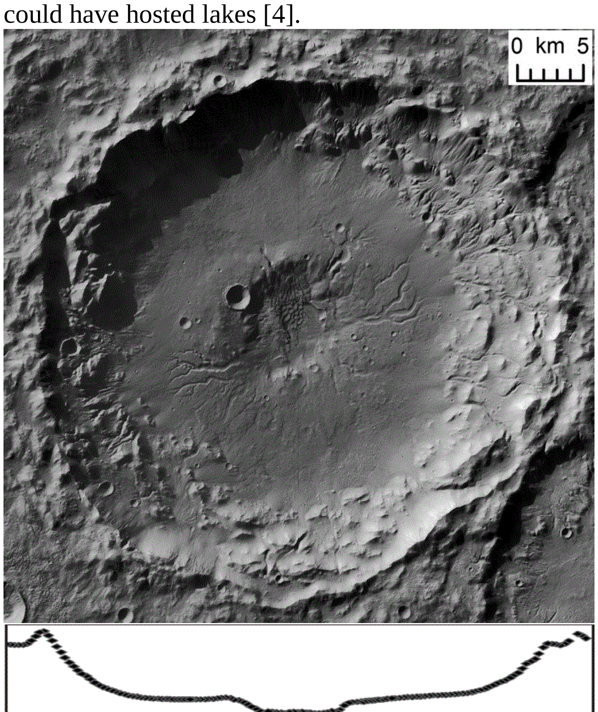

Fig. 1: (Top) Floor-type central pit crater (~40 km diam) with interior valley networks draining into the central pit (~500 m deep); in CTX [5]). (Bottom) MOLA PEDR [6] profile across the crater above. Vertical exaggeration of ~2.5.

Evidence for the past presence of lakes within the central pits of these craters include (1), identifications of outlet channels suggesting lake overflow [4], (2) sedimentary fans at the termini of valleys interpreted as deltaic in origin [4, 7], and (3) polygonal ground suggestive of dessication cracks [7]. Previously, only a limited number of these craters (5 of 96) were investigated to determine if paleo-lakes were ever present [4]. This abstract reports on the results of an on-going more expansive study [7], which builds on that previous work by increasing the number of craters inspected (all of the 96 craters for which the necessary data are available) and the breadth of criteria utilized. Here we report on our latest results.

Methods: *Outlet channels* – Central pit outlet channels are strong evidence of the overflow of past standing water from within the pit. To identify if any outlet channels are present, the floor of each CPC with valleys was inspected with the available Context Camera (CTX) images in ArcGIS. Digital Elevation Models (DEMs), created with CTX stereo pairs, were overlain atop of the CTX images and inspected to identify the channel slope direction. Those channels that breached the pit rim and had a slope direction away from the pit, were identified as central pit outlet channels. Thirty-six of the craters had sufficient data coverage to conduct this test.

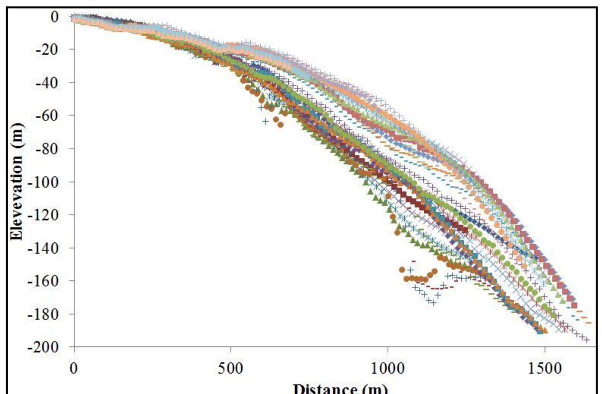

Fig. 2: Suite of 30 topographic profiles (for one sedimentary pit fan) exhibiting concave down morphology, consistent with a deltaic origin.

Sedimentary Fan Concavity – The concavity of sedimentary fans can be used to distinguish between alluvial and deltaic origins [e.g., 8]. Sedimentary fans were identified from CTX images covering the crater floors [5]. CTX DEMs, High Resolution Stereo Camera (HRSC) DEMs and Mars Orbiter Laser Altimeter (MOLA) Precision Experiment Data Records (PEDR) coverage of sufficient spatial resolution were collected for each fan. Topographic profiles were then taken across the fans (Fig. 2) observed within the central pits. The profiles of fans that were found to be concave down were then fit to a curve to determine if their concavity was consistent with that expected for pristine deltaic deposits. Six fans (in three craters) had sufficient preservation and data coverage for this test.

Sedimentary Fan Slope – Because the slopes of delta topset and foreset beds can be used to distinguish them from alluvial fan deposits [9-10], the topographic profiles of the sedimentary fans located within the central pits were investigated to determine their slope values (Fig. 3). The datas used were CTX DEMs, HRSC DEMs, HiRISE DEMs and MOLA PEDR points. Nine craters had fans that were appropriate for this test.

Fan Grain Size Distribution – The spatial distribution of sediment of different grain sizes within fans can be used to distinguish between an alluvial and deltaic origin [9-10]. For the sedimentary fans within central pits, Thermal Emission Imaging System (THEMIS) thermal inertia data [11] were used to identify if the fans had coarser grains on the steepest slope bounded by finer grain deposits (deltaic fan; Fig. 4) or coarser grains towards the apex and fine grains concentrated at the toes (alluvial fan). Six fans (within three craters) had the necessary preservation and data coverage for this test.

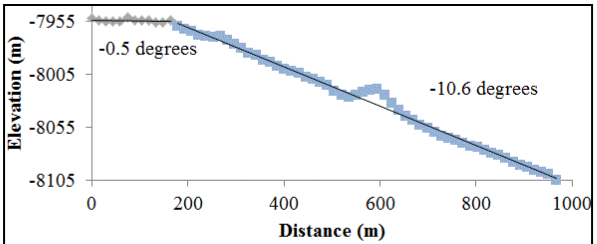

Fig. 3: Example of a slope profile across a sedimentary fan located within a central pit. The upper and lower slopes (-0.5 ° and -10.6°) are consistent with a deltaic origin.

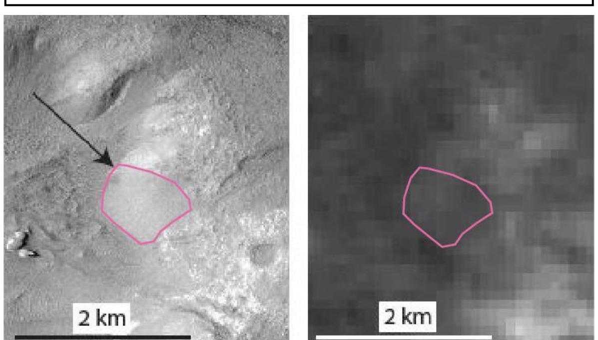

Fig. 4: (Left) Sedimentary fan in a central pit in CTX. (Right) THEMIS thermal inertia of the same area shows the fan has darker pixels (lower thermal inertia) at the apex (eastern extent of the fan) than on the higher sloped lower elevation section (western portion), consistent with coarser sediment on a delta front than on the delta plain [9].

Results to date: Two central pits have been found to have associated outlet channels, strongly supporting the hypothesis that they once hosted paleo-lakes. In two central pits, six sedimentary fans have been found to exhibit concave down morphology, consistent with deltas, and therefore support the past presence of a lake. To date, two sedimentary fans have been found to have slopes that match those expected for deltas. Only one fan has been found to exhibit patterns of thermal inertia consistent with a deltaic origin (although data coverage and mantling materials may be responsible for these limited thermal inertia results.)

Ongoing Work: *Spectral Signatures* – Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) data can be used to identify minerals that would be expected to be found in the deposits of a paleo-lake (e.g., carbonates, phyllosilicates and sulfates [12, and citations therein]). However, to support a central pit lake, these minerals would have to form in the lake and not simply be transported from the watershed. For this investigation, targeted CRISM observations are being used to identify these minerals present in the central pits (and not in the surrounding areas or crater walls). Thirty-two craters were available for this test.

Timing of the Paleo-Lakes – The presence of paleo-lake features have been documented repeatedly [e.g., 13-16]. In order to place the identified central pit paleo-lake features within the context of the greater aqueous history of Mars (e.g., Fig. 5), crater counting is being conducted on the crater ejecta that exhited more than 1 line of evidence in support of the hypothesis that they contained a lake at some time. Crater counts are being conducted in ArcMap using the CraterTools [17] application.

Conclusion: Our findings to date indicate that more CPCs hosted lakes than previously identified. The results of this global study will contribute to understanding of the location, amount, and timing of water on Mars.

References: [1] Smith, E. I. (1976) *Icarus* 28, 543-550. [2] Barlow, N. G. (2010) *GSA Sp. Papers 465*, 15-27. [3] Barlow, N. G. et al. (2017) *Met.s & Planet. Sci. 52*, 1371-1387. [4] Peel, S. E., Fassett, C. I. (2013) *Icarus* 225, 1, 272-282. [5] Malin, M.C. et al. (2007) *JGR:* Planets (1991-2012) 112(E5). [6] Smith, D. E., et al. (2001) *Geophys. Res*. 106, 23689-23722. [7] Peel, S. E., Burr, D. M. (2016) *LPSC 47*, abs.1024. [8] Moore, J. M., Howard, A. D. (2005) *JGR*: Planets 110. [9] James, N. P., Dalrymple, R. W. (2010) Facies Models 4. [10] Blair, T. C. McPherson, J. G. (1994) *J. Sed. Res*. A64, 450-489. [11] Fergason, R. L. et al. (2006) *JGR* 111, E12002. [12] Viviano-Beck, C. E. et al. (2014) *JGR*: Planets 119.6, 1403-1431. [13] Cabrol, N. A., Grin, E. A. (1999) *Icarus* 142, 160-172. [14] Cabrol, N. A, Grin, E. A. (2001) *Icarus* 149, 291-328. [15] Fassett, C. I., Head, J. W. (2008) *Icarus* 198, 37-56. [16] Carr, M. H., Head, J. W. (2010) *Earth and Pl. Sci.* Letters 294.3, 185-203. [17] Kneissl, T. (2011) PSS 59, 1243-1254.