AN ANALYSIS OF CANDIDATE CLOSED-BASIN LAKES IN IMPACT CRATERS ON MARS. K.L. Aureli.[1], J.W. Head[2], T.A. Goudge[2], C.I. Fassett[3]. [1]Dept. of Astronomy, University of Massachusetts, Amherst, MA 01002. [2]Dept. of Geological Sciences, Box 1846, Brown University, Providence, RI, 02912; [3]Dept. of Astronomy, Mount Holyoke College, South Hadley, MA. (Contact: kaureli@student.umass.edu)

Introduction: Past studies have shown that fluvial activity was once more widespread across the southern highlands than previously thought, including the formation of candidate paleolakes which have been classified as being either open (i.e., having both an inlet and outlet valley) or closed (i.e., having only an inlet valley) [e.g., 1-3]. Previous analyses of closed-basin lakes (CBLs) on Mars used Viking Orbiter data [1,2] to identify candidate paleolake sites. Using recently acquired high-resolution data [4-7], we present an updated catalog of candidate closed-basin lakes found in impact craters.

Methods: This analysis used a combination of gridded topographic data from the Mars Orbiter Laser Altimeter (MOLA) [4] and the ~100m/pixel global daytime infrared mosaic from the Thermal Emission Imaging System (THEMIS) [5] to recognize inlet valley features debouching into candidate paleolakes in impact craters. Additionally, Mars Reconnaissance Orbiter (MRO) Context Camera (CTX) [6] and High Resolution Imaging Science Experiment (HiRISE) [7] images were used for higher-resolution examination of candidate inlet and outlet valleys.

To execute the search, a grid from 60°N to 60°S across all longitudes was used to search for impact craters with inlet channels but no apparent outlet channel. To distinguish them from open-basin lakes [3] and to be included in the catalog, the impact crater must have an inlet valley based on present topography as well as no identifiable outlet valley (Fig. 1).

Results: Based on our search we found evidence for 387 possible closed-basin lakes that are widespread across the southern highlands (Fig. 2). From the 387 closed-basin lakes we found, we identified three different types of inlet channels that we have termed: short, long and interior dissection. Examples of each type are shown in Figure 1.

Short Inlets. Craters mapped as having short inlets are those whose inlet valleys breach the crater rim but have abrupt origins and do not extend far away from the crater rim, typically less than 10 km (Fig. 1a). We identified 281 craters (~73% of the total catalog) as candidtae closed-basin lakes with short inlets. Within these candidate closed-basin lakes, 36 had an associated sedimentary deposit (e.g., alluvial fans or deltas). Some of these associated sedimentary deposits provide evidence of a past standing body of water, and also provide an indication of the approximate level of ponded water (i.e., to the topset of the delta deposits). It is interesting to note that the majority of the sedimentary deposits found in our entire survey of 387 craters (~88%) were accompanied by this type of inlet.

Long Inlets. Closed-basin lakes with long inlets were identified in 34 craters (~8%). To be mapped as a long inlet closed-basin lake, the inlet valley had to breach the rim of the crater and extend out from the crater rim to lengths typically greater than 25 km (Fig. 1b). These inlet valleys are often part of larger drainage systems with contributing tributaries, and many of the long inlet channels displayed characteristics similar to typical valley networks [e.g., 8]. In four of these candidate paleolakes, evidence for an associated sedimentary deposit was found. Gale Crater, currently being explored by Mars Science Laboratory, is an example of this type of closed-basin lake.

Interior Dissection. Interior dissection, with examples of fluvial activity only on the interior walls of the crater, and no breach of the crater rim, characterized 72 candidate closed-basin lakes (Fig. 1c). An associated sedimentary deposit was found in only one of these paleolakes.

Geographical Distribution. The candidate closed-basin lakes found in this study are widely distributed across the southern highlands. There is a high concentration between 65°W and 110°E and near the dichotomy boundary. The global distribution of each type of inlet valley can be seen in Figure 2. The short inlets (white dots), are found across several terrains with concentrations in the Arabia Terra-Noachis Terra region as well as Terra Sabaea. Long inlets (black dots), are found across several regions as well, including the Terra Sabaea and Terra Cimmeria regions. Candidate closed-basins with substantial interior dissection (red dots) are spread across several different terrains.

It is interesting to note that, to first-order, the global distribution of the candidate closed-basin lakes is similar to that of the 210 open-basin lakes studied by [3] (green dots), which are also widespread across the southern highlands. There is, however, a high concentration of short inlet closed-basin lakes in the Arabia Terra region (20°N, 30°E) where few open-basin lakes are found.

Discussion: Our results indicate that candidate closed-basin lakes are far more widespread than suggested by previous studies [e.g., 1,2], due to our use of more recent, higher resolution data. It is difficult to say definitively that all of these breached impact craters were indeed lakes (i.e., had standing water); having an inlet does not mean that water ponded within these craters to form lakes. The presence of an inlet and lack of an outlet does, however, enable us to assess maximum levels of flooding within these potential paleolakes, as they can not have been flooded to a level where the crater rim would have been breached to form an outlet. Such analyses are underway.

In terms of timing it is not yet clear whether all of these candidate closed-basin lakes were active during the same period of martian history. Long, integrated inlet channels with typical valley network morphology [e.g., 8] appear to be rare; it may be that the fluvial activity associated with the other types of candidate closed-basin lakes (short inlet and interior dissection) was not contemporary with the majority of valley network formation on Mars, typically thought to have ceased near the Noachian-Hesperian boundary [e.g., 8]. This is a very important question for constraining the timing of fluvial activity on the surface of Mars, and is being actively pursued.

Future Work: In order to further characterize the catalog of closed-basin lakes presented here, we are collecting morphometric data on the candidate closed-basin lakes. This includes maximum lake volumes, areas, elevation of the lowest point on the rim (i.e., where an outlet valley would have breached based on current topography), shoreline length, shoreline development index, degradation state of the crater using the crater degradation criteria outlined by [9], and resurfacing mechanisms for each basin [e.g., 10].

References: [1] Cabrol, N. and Grin, E. (1999) *Icarus*, **142**:160. [2] Cabrol, N. and Grin, E. (2001) *Icarus*, **149**:291. [3] Fassett, C. and Head, J. (2008) *Icarus*, **198**:37. [4] Smith, D. et al. (2001) *JGR*, **106**:23,689. [5] Christensen, P., et al. (2004) *Space Sci. Rev.* **110**:85. [6] Malin, M. et al. (2007) *JGR*, **112**:E05S04. [7] McEwen, A., et al. (2007), *JGR*, **112**:E05S02. [8] Fassett, C. and Head, J. (2008) *Icarus*, **195**:61. [9] Mangold, N. et al. (2012) *JGR*, **117**:E04003. [10] Goudge, T. et al. (2012) *Icarus*, **219**:211.

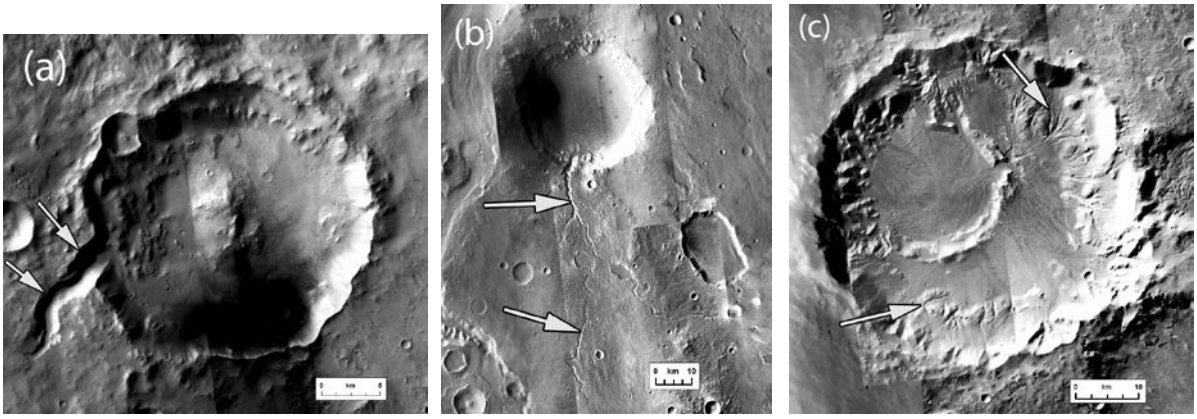

Figure 1. Example of each type of candidate closed-basin lake reported in the text. (a) Short inlet, 144.06°E, 9.547°S; CTX images used: P16_007158_1703, B02_010230_1715. (b) Long inlet, 58.732˚W, 5.529˚N; CTX images used: P20_008866_1844, P03_002247_1847, B17_016369_1853,B17_016158_1882, background is global, 100 m/pixel THEMIS mosaic. (c) Interior dissection, 45.332˚W, 23.634˚S; CTX images used: B19_018874_1561, B18_016540_1579, B07 012360 1561. Arrows show location of inlet features (a,b) and interior dissection (c).

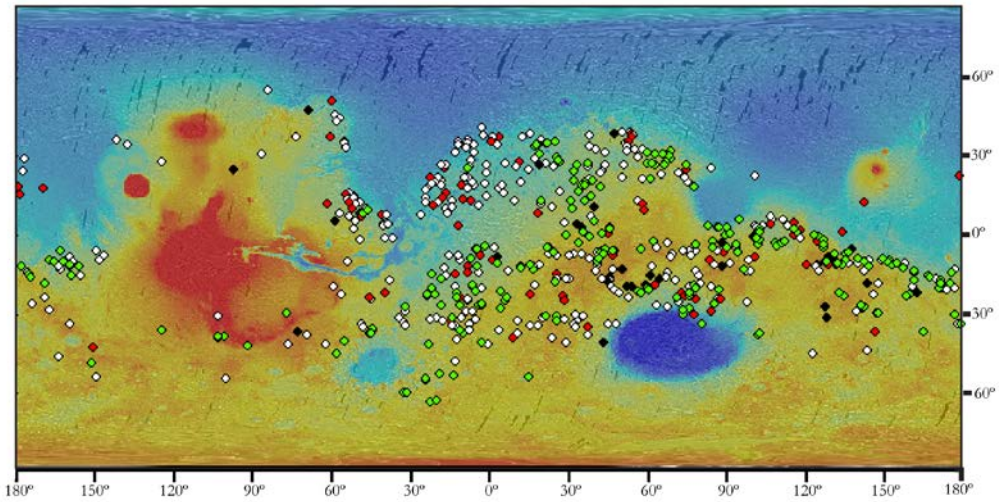

Figure 2. Global distribution of candidate closed-basin lakes on Mars. Short inlets (white dots), long inlets (black dots), interior dissection (red dots) and open-basin lakes (green dots). Background image is a topographic map of Mars (MOLA), overlain on the global, 100 m/pixel THEMIS mosaic.