INITIAL RESULTS FROM A SURVEY OF RIMLESS DEPRESSIONS ON MARS USING THEMIS AND MOLA DATA. J. S. Drake, School of Earth and Space Exploration, Arizona State University, Tempe, AZ, 85287 jdrake@mars.asu.edu

Introduction: Circular and elliptical depressions, distinct from impact craters by their steep walls, lack of visible rims or ejecta, and flat floors, have been identified in Viking imagery at several locations on Mars, including Chryse Planitia [1], Utopia Planitia [2], and Ares Valles [3]. More recently, narrow-angle MOC and HiRISE data have been applied to the study of such features, resulting in the discovery of several new sites of interest, and permitting the examination of previously-identified areas in unprecedented detail [4,5,6]. Several possible interpretations of these features have been suggested, including volcanic pit craters, aeolian deflation, and periglacial processes such as thermokarst [7,8]. This research endeavors to discriminate between these competing theories by conducting a comprehensive survey of this interesting morphology, potentially providing clues to Mars' climate history in the process.

Data and Methods: While the utility of high-resolution instruments in such studies is beyond question, their narrow viewing angle severely limits their ability to conduct such a survey. The THEMIS instrument aboard Mars Odyssey, by contrast, has imaged nearly 100% of the planet at 100m resolution, making it ideal for such a project. While the price of this coverage is limited resolution, nearly all the sites identified in the literature are readily discernible in THEMIS infrared imagery (fig. 1).

Approximately 50,000 THEMIS IR images were assembled to create a mosaic of the entire planet from +50º to -50º latitude. Divided into segments ten degrees square, this mosaic was then systematically examined for features consistent with the target morphology. Upon initial examination, over 12,000 candidate sites were identified. These were then reexamined and classified by diameter, circularity, and a subjective confidence criterion that expresses their resemblance to the type localities. All candidate sites were co-registered with altimetry from the Mars Orbiter Laser Altimeter. In regions of particular interest, THEMIS visible and MOC imagery was also obtained.

Results: Of all candidate sites, approximately 10,000 were ultimately rejected as too different from the target morphology to be counted. The locations and sizes of the remainder are shown in figure 2, color-coded by altitude. In addition to the locations mentioned in the literature, perviously undocumented concentrations of pits are present in northwest Hellas basin, in Terra Cimmeria, and even in Arcadia.

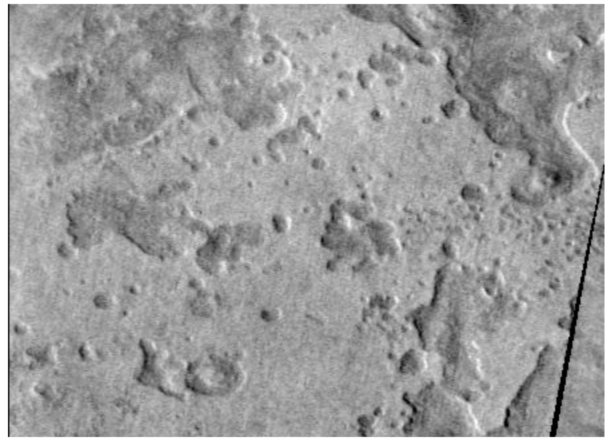

Fig. 1. Rimless depressions in Utopia Planitia as they appear in THEMIS infrared imagery (45.9ºN, 90.4ºE, res.100m/px).

Strikingly, with the exception of Terra Cimmeria, almost no concentrated aggregations are present at elevations above the planetary datum. Instead, most sites at altitudes greater than zero meters appear to be scattered sparsely across the southern highlands, seemingly at random. That the depressions show a clear preference for lower altitudes is illustrated in figure 3.

A similar trend is visible in latitude (fig. 4), with the northern mid-latitudes harboring a far greater density of pits than elsewhere. The sole exception to this bias is visible in Ares Valles and Chryse Planitia, where the depressions correspond to the channel and its outwash plain with remarkable fidelity. The major volcanic regions are noticeably devoid of the features, either scattered or clustered. In the case of Syrtis Major, however, some clustering is apparent about its periphery. No clear trends in diameter are visible on a global scale.

Interpretation: Two distinct populations of depressions appear to be present in this survey. The first and most abundant is characterized by high-density clusters and is generally confined to low elevations and middle latitudes. The second is more scattered, and populates the cratered highlands, particularly in the southern hemisphere. Because the majority of sites belong to the first group, the striking dichotomy between the northern and southern mid-latitude zone visible in figure 4 is likely due to the relative dearth of low-elevation terrain in the south.

The latitude and altitude dependences of the clustered depressions are consistent with their presence being controlled by a combination of temperature and

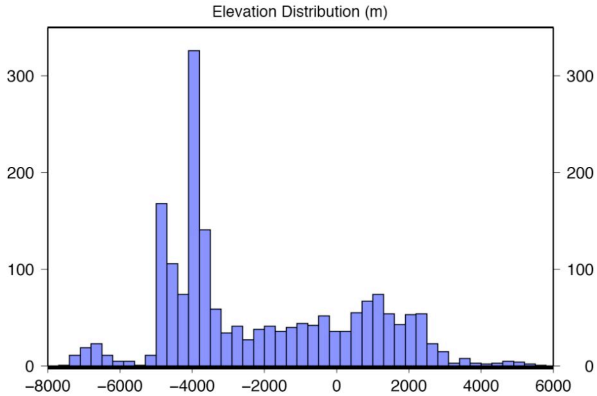

Fig. 3. Elevation distribution of target morphology, 300m bins.

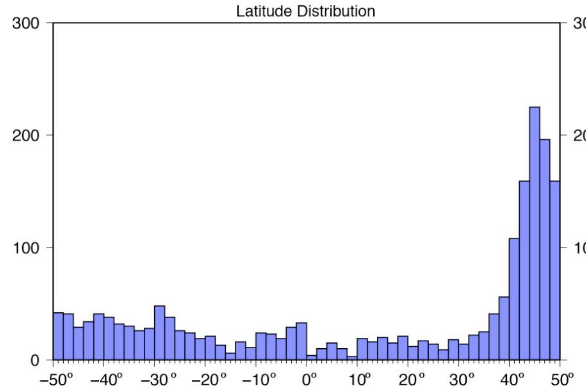

Fig 4. Latitude distribution of target morphology, 2° bins.

pressure, respectively. These controls would not operate on volcanic landforms, and it is likewise difficult to envision a scenario in which an exclusively aeolian formation mechanism would operate in such a latitude-constrained manner. Finally, abundant geomorphic evidence and theoretical models exist that indicate the presence of ice in the mid-latitudes [9,10,11]. For the majority of features, the periglacial interpretation is therefore preferred. The data are more equivocal concerning the origin of the highland group, though the lack of features in Tharsis seems to argue against the volcanic interpretation.

Future Work: The periglacial interpretation of these features requires the presence of massive ground ice. Subsequent analysis will focus on a more detailed morphologic investigation of the regions where clustered depressions are present at high density, particularly those that have not yet been described in the relevant literature. Individual MOLA tracks have already been obtained for many of these areas, and a survey is underway to document any systemic variations in the pits' depth with the goal of constraining the volume of this ice. Additionally, any signs of fluvial drainage, particularly the "beaded stream" morphology typical of terrestrial thermokarst will be thoroughly investigated.

References: [1] Costard, F.M. and Kargel, J.S. (1995). *Icarus,* 114, 93 - 112. [2] ibid. [3] Costard, F. (1987). *Z. Geomorph. N.F.,* 31, 243-251 [4] Page, D.P. (2007). *Icarus,* 189, 83-117. [5] Chapman, M.G. et al. (2003). *JGR,* 108 (E10), 2-1 - 2-20. [6] Soare, R.J. et al. (2007) *LPS XXXVIII,* Abstract #1440. [7] Ghatan, G.J. et al. (2003) *JGR, 108,* 11-1 – 11-19. [8] Soare, R.J. et al. (2005) *LPS XXXVI,* Abstract #1103. [9] Christensen, P.R. (2003) *Nature* 422, 45-48. [10] Squyres, S.W. and Carr, M.H. (1986) *Science* 231, 249-252. [11] Paige, D.A. (1992) *Nature* 356, 43-45.

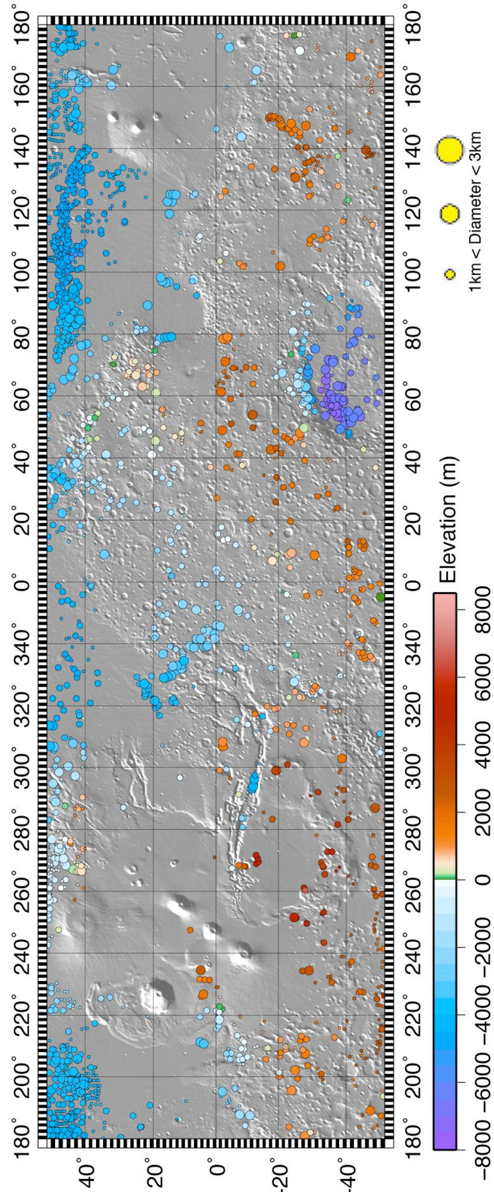

Fig. 2. Aerographic distribution of rimless depressions on Mars, over MOLA shaded relief. Circle size indicates maximum diameter.