SMALL, YOUNG FLUVIAL FEATURES IN ICY TERRAINS ON MARS. C. I. Fassett, J. L. Dickson, and J. W. Head. Box 1846, Dept. of Geol. Sci., Brown University, Providence, RI 02912. (Caleb_Fassett@brown.edu)

Background: The success of recent missions has led to important advances in our understanding of the martian fluvial record. There has been considerable expansion in the number and extent of mapped valley networks [1], as well as recognition of many valley-related sedimentary deposits [e.g., 2]. These new data also revealed that many valley systems feed basins with outlets, implying that numerous open-basin lakes existed (~215) at a wide range of spatial scales when valley networks were active on Mars [3]. In some cases, these basins were linked in lake chains up to thousands of km in length [2,3], illustrating the continuity and intensity of the surface hydrological system.

Our recent study using buffered crater counting [4] suggests that the large, integrated highland valley networks on Mars were last active before the end of the Early Hesperian (N(5)>155)(the Late/Early Hesperian boundary is at N(5)=125; the Hesperian/Noachian boundary is at N(5)=200 [5]). If the end of the major phase of highland valley network activity was a single point in time, our data suggest this occurred at approximately the Noachian/Hesperian boundary (N(5)~187-214).

However, these results do not imply that all valley formation entirely ceased on Mars at this time. Indeed, it has long been suggested that some activity continued at later periods in specific environments, such as on the flanks of some volcanoes [6] and around Valles Marineris [7]. Formation of valleys on the flanks of the volcanoes may have been aided by special local conditions (e.g., energy availablity provided by the volcanoes themselves) which helped enable melting of surface or subsurface ice in conditions otherwise inhospitable to surface melting [8, 9]. Gullies, which appear to be a distinct class of features formed exclusively on steep slopes in mid- to high-latitudes, are another example of very young fluvial systems on Mars; both stratigraphic constraints and crater counts imply activity within the last ~5 Myr [10-12].

Thus, some valley formation on Mars has occurred on Mars after the Early Hesperian, but at greatly reduced scale and intensity. This shift in scale likely reflects a major change in conditions from a more clement environment to the cold, hyperarid desert that exists today. As environmental conditions changed, local conditions became of paramount importance for valley formation.

In this abstract we document a distinct class of small valleys which appear to be directly associated with ice at the surface or in the near-surface, and which most likely formed during the Amazonian. These small valleys are distinct from gullies that occur in similar regions, because they form on surfaces with much lower slope (<<10°) and have distinctive morphologies (for example, no alcoves and only rare fans).

Small Valleys in Icy Terrains: Mars has a number of surface features long thought to show morphological evidence for ice, either as a result of vapor-diffusion [13,14] or debris-covered glaciation [15,16]: lobate debris aprons (LDA), lineated valley fill (LVF), and viscous flow features (VFF). Indeed, the interpretation that some of these features have *extant* ice is now supported by direct observations of the SHARAD experiment [17, 18]. We have systematically surveyed CTX data released to the PDS (through mission phase P16) to search for possible fluvial features associated with these icy regions. The distribution of candidate fluvial features is concentrated in two latitude bands: 25-50 ºS and 30-55ºN (Fig. 1). Here we describe a few example environments:

Valleys on the margin of LDA/VFF: Figs. 2-4 show examples of small valleys on the margin of LDAs or beneath VFF. In each instance, valleys begin at the margin of the LDA, and have nearly constant widths downslope. Fig. 4 shows evidence for a small sediment fan at its termination. Other small valleys of this class have been observed by [19].

Valleys on a LDA surface: A single small sinuous valley extends across the surface of a LDA in the eastern Acheron Fossae region for at least ten kilometers, transitioning into a ridge at the end of the apron. Its highly sinuous morphology is very suggestive of a fluvial origin; since it must post-date the apron it incises, it is likely of Amazonian age.

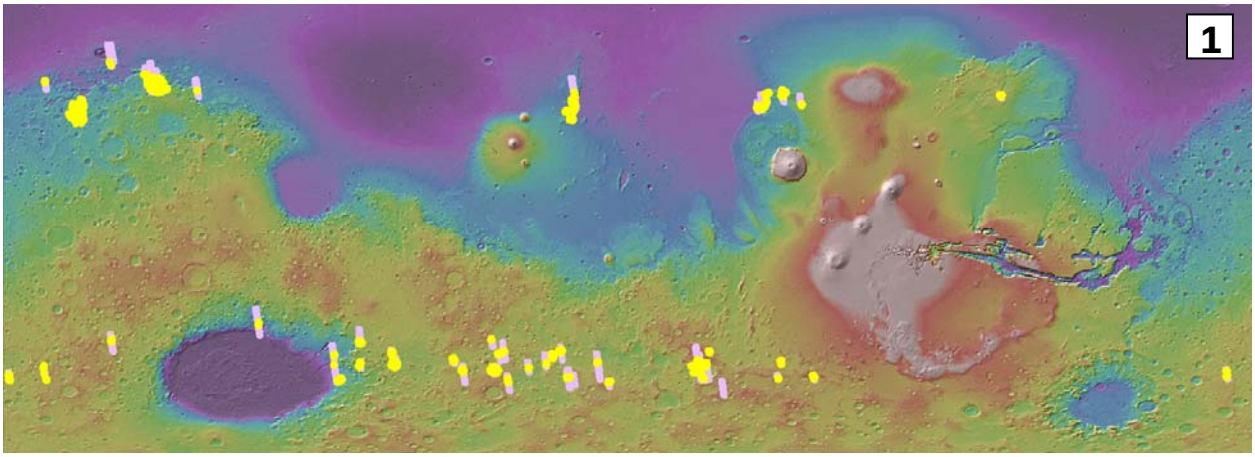
Interpretation: The geological setting and morphology of these valleys suggests they may be analogous to fluvial systems in ice-marginal terrains on Earth, which form by melting of glacial ice. Note that the existence of these valleys does not require wet-based glaciation; in the Antarctic Dry Valleys, some cold-based glaciers melt at their termini where peak summer insolation is particularly strong, leading to vigorous flow in ice-marginal streams [20]. The precise conditions that favored melting at these locations on Mars are presently unknown.

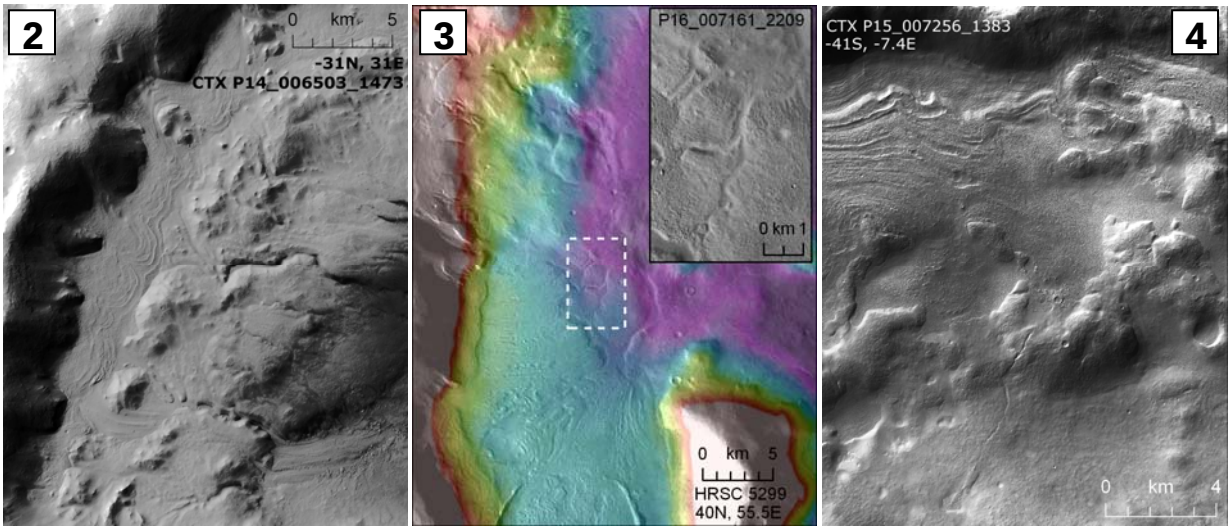
Age: Establishing the age of these small valley features is challenging. If they are caused by melting LVF/LDA/VFF, as we interpret, they are likely to be Mid-to-Late Amazonian based on the age of those features. However, in some instances we have stronger constraints. The valleys found on the floor of Lyot crater, which as we describe in a companion abstract [21], must be Early Amazonian or younger on the basis of both crater counting and stratigraphy.

Conclusion: Mars has a population of small valleys in ice-rich terrains, many of which are Amazonian in age. Based on their association with ice-related features, the most likely mechanism for forming these small valleys is melting of ice. These small valleys are qualitatively different from the Noachian valley networks, but consistent

with the view that Mars has experienced fluvial activity throughout its history.

References: [1] Hynek, B.M. et al. (2008), *LPS XXXIX*, abs #2353. [2] Irwin, RP et al. (2005), *JGR*, *110*, E12S15. [3] Fassett, C.I., Head, J.W. (2008), *Icarus*, *198*, 37-56. [4] Fassett, C.I., Head, J.W. (2008), *Icarus*, *195*, 61-89. [5] Tanaka, K.L. (1986) *JGR*, *91*, E139-E158. [6] Gulick, V.C., Baker, V.R. (1990), *JGR*, *95*, 14,325-14,244. [7] Mangold, N. et al. (2004), *Science*, *305*, 78-81. [8] Fassett, C.I, Head, J.W. (2006) *Planet. Space Sci.*, *54*, 370-378. [9] Fassett, C.I., Head, J.W. (2007) *Icarus*, *189*, 118-135. [10] Malin, M.C., Edgett, K.S. (2000), *Science*, *288*, 2330-2335. [11] Reiss, D. et al. (2004), *JGR*, *109*, E06007. [12] Schon, S.C. et al., (2009), this meeting. [13] Squyres, S.W. (1978) *Icarus*, *34*, 600-613. [14] Squyres, S.W. (1979) *JGR*, 8087-8096. [15] Head, J.W. et al. (2005), *Nature*, *434*, 346-351. [16] Head, J.W. et al. (2006), *EPSL*, *241*, 663-671. [17] Holt, J.W. et al. (2008), *Science*, *322*, 1235-1238. [18] Plaut, J.J. (2008), *GRL*, in press. [19] Berman, D.C. et al., (2009) *Icarus*, in press. [20] Fountain, A. et al. (1999), *BioScience*, *49*, 961. [21] Dickson, J.L. et al. (2009), *this meeting*.





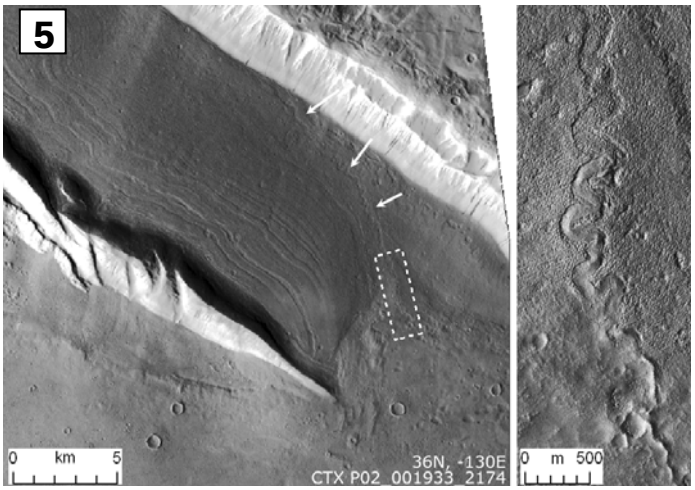


Fig. 1. Location map for candidate ice-related small valleys.

Fig. 2. Moderately sinuous valleys at the eastern margin of a lobate apron in a crater west of Hellas. These valleys incise a ~5º slope from west to east.

Fig. 3. Small valleys adjacent to a LDA in the Coloe Fossae region along the dichotomy of Mars. These valleys are on ~1-2º slope.

Fig. 4. A small, single valley on a ~5º slope from north to south below a degraded VFF/LDA in a crater ENE of Argyre. At its termination, this small valley has a fan of material.

Fig. 5. Very sinuous valley on the surface of a LDA in Acheron Fossae (~1º slope, from north to south), terminating in a ridge (esker? inverted valley?).