MORPHOLOGIC CHARACTERISTICS AND GLOBAL DISTRIBUTION OF PHREATO-VOLCANIC CONSTRUCTS ON MARS AS SEEN BY HiRISE. W. L. Jaeger[1], L. P. Keszthelyi[1], D. M. Galuszka[1], R. L. Kirk[1], and the HiRISE Team, [1]U.S. Geological Survey, Flagstaff, AZ 86001 (wjaeger@usgs.gov).

Introduction: The floor of Athabasca Valles, Mars, is peppered with thousands of ring-mound landforms that are phreato-volcanic in origin [1]. They formed when a voluminous lava flow flooded the channel system, superheated groundwater in the substrate, and receded, reducing the overburden pressure and, thereby, allowing the groundwater to boil. Steam exploded through what remained of the deflating lava flow, producing a variety of landforms that exhibit a continuum between ring- and mound-shaped features. Based on these pristine examples in Athabasca Valles, we have developed a set of criteria for identifying this class of phreato-volcanic construct (PVC) on Mars and have completed an initial examination of other potential PVC sites.

Morphologic Characteristics: The Athabasca Valles/Elysium Planitia PVCs were recognized as likely phreato-volcanic (a.k.a. 'rootless') cones from MOC images [2], allowing their basic morphometry and spatial distribution to be well quantified. While HiRISE images allow these numbers to be measured with better precision, they do not change the earlier results: the range of size and shapes, as well as the spatial distribution, fall within the range of Icelandic rootless cones [3-5].

New measurements are being extracted from the digital elevation model (DEM) produced from HiRISE stereo pair PSP_002661_1895 and PSP_003294_1895. The typical heights of the PVCs range from ~5-10 m for ~20±7-m-diameter mound-shaped features and ~31±11-m-diameter pitted cones to < 5 m for ~44±15-m-diameter raised rings. The exterior slopes of the PVC walls are ~30°, but the interior slopes are often overhanging. This confirms that the PVCs are composed of agglutinated spatter rather than uncemented clasts. The gross topography of these features is consistent with Icelandic rootless cones.

The PVCs in Athabasca Valles do exhibit some morphologic characteristics that are not observed in their Icelandic counterparts. These are most notably moats and wakes. The moats formed as the thin crust sagged and structurally failed to varying degrees under the weight of the cones [1]. The DEM shows that the moats are typically ≤ 1 m deep and ~12 m wide. The wakes formed when the brittle lava crust rafted over steam sources that were fixed to the substrate, mimicking at a very small scale the formation of the Hawaiian-Emperor Seamount Chain [1].

The moats and wakes are seen on Mars, but not in Iceland, because the Icelandic examples did not form atop a thin translating crust. I.e. the moats require the solid crust to be thin and the wakes require it to be mobile. The lava flows upon which the Icelandic rootless cones formed were long-lived laminar inflated pahoehoe flows with thick, stable crusts [6].

Another aspect of these cones that is not observed in Iceland is that they preferentially form where the flow is thin. Cones can be seen outlining the rims of impact craters that have been completely buried by the lava flow. Topographic benches along the margins of the flood-eroded channel are marked by continuous chains of rings and cones. Very small cones can be found on the highest plateaux that the lava reached. Jaeger et al. [1] explain this distribution as a reflection of where steam would be the most likely to erupt through the lava flow (e.g., locations where the steam budget was greatest and/or the overburden pressure was lowest). The DEM opens the door for more quantitative studies of the steam movement underneath the lava flow.

Global Distribution: While conical landforms can form by a variety of disparate processes, the distinctive assemblage of cones, wakes and annular moats is diagnostic of phreato-volcanism and is readily observable in high-resolution orbital imagery. With HiRISE, we have systematically targeted candidate cone fields identified in lower resolution data in order to ascertain the global distribution of this class of PVCs.

We find the aforementioned assemblage in serveral locations along the southern and western margin of Amazonis Planitia and the southern margin of Arcadia Planitia (Fig. 1). Figure 2 shows some examples of PVCs in southern Arcadia Planitia.

Similar cones are seen in one location in Utopia Planitia, across much of Isidis Planitia, and a few localities north of Olympus Mons (Fig. 1). However, these sites do not exhibit wakes, moats, or an obvious spatial association with buried topography. While it is possible that these are phreato-volcanic cones that were built atop a more stable (i.e., thicker and immobile) lava surface, the current evidence is equivocal. In fact, it is not certain that the host material for the cones is a lava flow. We also note that there are cones in the Utopia, Acidalia, and Cydonia regions with a very different morphology [7, 8]. We do not include these features in our global inventory of likely phreato-volcanic constructs.

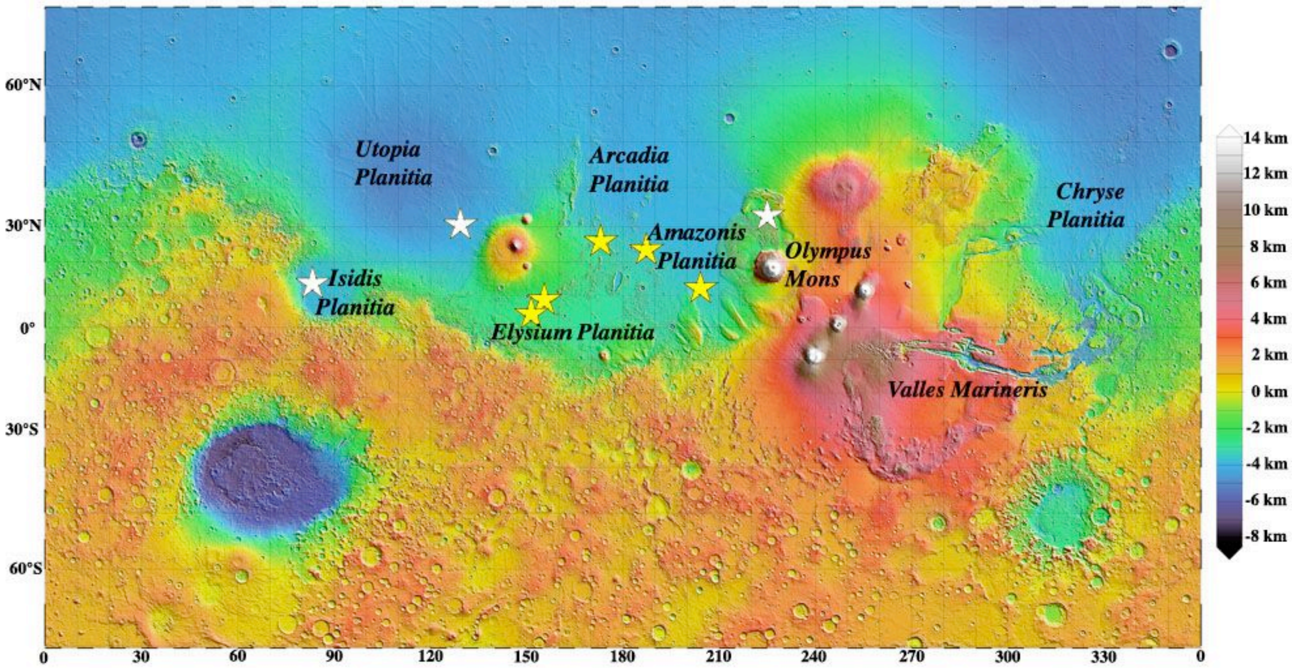

Figure 1. Global distribution of candidate fields of phreato-volcanic constructs on Mars. Those indicated by yellow stars manifest an assemblage of features diagnostic of phreato-volcanism. Those indicated by white stars may also be phreato-volcanic in origin, but the interprtation is less certain.

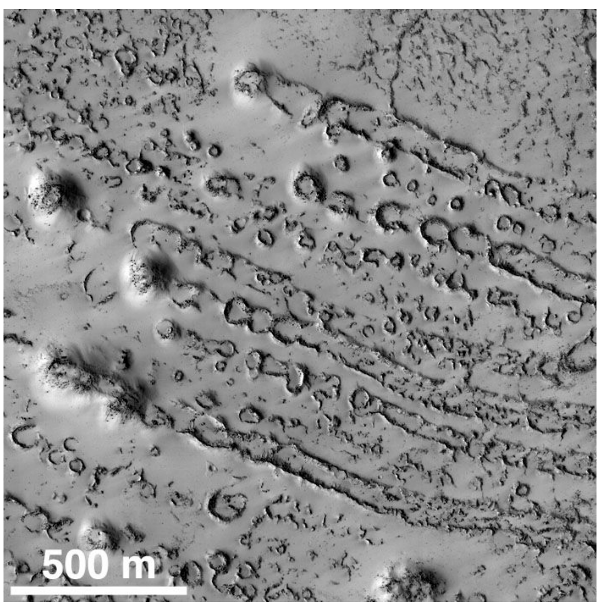

Figure 2. Portion of HiRISE image PSP_006748_2060 showing wakes transitioning to chains of PVCs in southernmost Arcadia Planitia. The smooth, lighter-toned material surrounding the cones is a blanket of dust.

The current global distribution of PVCs with associated wakes and moats is a good match to the locations where there is evidence for both young flood lavas and recent fluvial activity. This implies that such features should have been abundant in the distant past when Mars was more active both volcanically and fluvially. However, the landforms we examined that were not associated with the pristine Athabasca Valles flood lavas are significantly degraded. This suggests that it will be very challenging to use photogeology to identify similar lava-water interaction features that formed in the Hesperian, much less the Noachian.

References: [1] Jaeger W. L. et al. (2007) *Science, 317*, 1709-1711. [2] Lanagan P. D. et al. (2001) GRL, 28, 2365-2367. [3] Greeley R. and Fagents S. A. (2001) JGR, 106, 20527-20546. [4] Bruno B. et al. (2006) JGR, 111, 2005JE002510. [5] Jaeger W. L. et al. (2008) LPSC 39, Abstract #1836. [6] Fagents S. A. and Thordarson Th. (2007) *Geology of Mars*, 151-177. [7] Farrand W. H. et al. (2005) *JGR, 110*, 2004JE002297. [8] Dundas C. M. et al. (2007) *LPS 38*, Abstract #2098.

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