POST-GLACIAL DIKE EMPLACEMENT EVENT AT ARSIA MONS, MARS: ERUPTIVE SPATTER CONES, TEPHRA CONES AND FLOWS ALONG A DIKE-RELATED FISSURE. J. W. Head[1], D. E. Shean[1]. and L. Wilson[2], [1]Dept. Geol. Sci., Brown Univ., Providence RI 02912 USA, [2]Environ. Sci. Dept, Lancaster Univ., Lancaster LA1 4YQ, UK (james_head@brown.edu).

Introduction: The melting of planetary interiors, segregation of melt products, ascent, intrusion and eruption of magma, and outgassing to the atmosphere are among the most fundamental processes in the thermal and geological evolution of terrestrial planets. Commonly, much of the record of these processes remains in the subsurface, and an understanding of the processes relies heavily on interpretation of surface deposits and exposures, which are often easily erodable, covered by their own effusive products, or are difficult to distinguish in a sea of similar deposits. Dike systems (solidified magma-filled cracks propagated from the source regions toward the surface) represent one of the key elements of the shallow subsurface manifestation of these processes, but are rarely exposed on planets with little differential uplift and erosion, such as the Moon, Mars, Mercury and Venus. On Mars, the presence of linear volcanic vents, narrow graben (the surface manifestation of near-surface dike intrusion) [1], and narrow linear ridges (the erosional remnants of near-surface dike systems) [2,3] represent some of the best evidence yet seen for the nature and distribution of planetary dike systems. Examples of dike emplacement events ideal for study would be those that 1) represent single emplacement phases, 2) form on non-volcanic deposits so that eruptive products associated with the dike emplacement event can be distinguished from previous material, and 3) are not covered by continued post-emplacement volcanism. Amazonian-aged deposits on the western flanks of the large Tharsis Montes volcanoes (Arsia, Pavonis, and Ascraeus Mons) have been recognized to be of glacial origin [4-7] and represent such a late-history non-volcanic baseline. We report here on the documentation of a linear and laterally extensive cone and lava flow system (Fig. 1) interpreted to be the near-surface manifestation of a major dike emplacement event in the Amazonian, postdating the major glacial deposits and unmodified by subsequent volcanism. Analysis of this feature permits the assessment of eruption conditions associated with the emplacement of a single large dike in the Tharsis volcanic province.

Geological setting: The volcanic cones and flows shown in Fig. 1 occur just northwest of Arsia Mons, one of the major shield volcanoes of the Tharsis region. They are largely superposed on the Arsia Mons fan-shaped deposit, interpreted to be of glacial origin [e.g., 5], which provides a key baseline to help distinguish the dike emplacement event from other volcanic deposits of the Arsia and Tharsis region. The deposit itself consists of a row of cones and adjacent flows superposed on the ridged facies of the glacial deposit, thought to represent drop moraines from the previously emplaced cold-based piedmont glacier [5]. The strike of the row of cones is ~N5E, not radial from the center of Arsia. The row of cones and related flows has been traced for a distance of ~27 km in the fan-shaped deposit and several cones aligned along strike suggest that it extends for several tens of km to the NW of the fan-shaped deposit.

Within the fan-shaped deposit, two major developments of linear cones occur. The southern one, covered in a MOC image, consists of at least 44 aligned discrete cones over a distance of about 7.3 km. The second one, covered in a THEMIS image, is about 11.3 km in length and consists of about 50 cones. Individual cones are equidimensional to slightly elongate along the direction of strike and average less than 100 m in width and are typically 20-25 m in height. Several of the cones in each area of development are broader, up to ~600 m in width, and noticably taller. Some cones, typically toward the ends of the rows, show no surrounding flow deposits, while others show evidence for flanking lava flows extending for distances of 2-3 km from the cones. The larger cones, some of which have summit craters, appear to be the focal point for more extensive flanking flows, extending as much as 5-15 km from the vicinity of the cones. The paths of these latter flows are controlled by 1) the regional NW slope on the flanks of Arsia, 2) topography of the underlying lava flows and the glacial deposits, and 3) local slopes associated with the ridges of the glacial deposits.

Nature of dike emplacement events and interpretation of eruption conditions: Commonly, when a dike is emplaced, it rises to the near surface along most of its length and the top stalls at a depth of a few meters to a few hundred meters, depending on local crustal density distribution, stress levels, and orientations, magma overpressurization levels and gas content and exsolution patterns [e.g., 8-9]. Often, a small portion of the dike intersects the surface, and creates a short-duration "curtain of fire" eruption developing into a longer-duration centralized vent (e.g., 10), forming. a row of small spatter cones, a centralized tephra cone and flanking lava flows. The geometry of the cones and the typical distances of flanking flow features can be used to infer eruption conditions [e.g., 11-12]. On the basis of the geometry of the cones and flows described above, dike widths of less than a meter are implied with rise speeds in the range of a few cm/s, comparable to those typical of Kilauea eruptions on Hawaii. Cone widths imply pyroclastic velocities of about 50 m/s, which could be generated by magma containing 0.1% exsolved water as the magmatic gas. On the basis of the length of the longest flows, the eruption duration is likely to have been of the order of days.

Conclusion and implications: This preliminary analysis shows that a dike emplaced in the Tharsis rise volcanic complex has characteristics similar to those of a typical terrestrial eruption at Kilauea, Hawaii. The scale and geometry of the cones also indicates that Tharsis magmas were not depleted in volatiles late in the eruptive history of the region. This example underlines the importance of searching for additional cases which provide the unambiguous information necessary for this type of reconstruction. Unlike this example, many of the dikes that characterize Tharsis volcanoes earlier in their history are much larger and are radial to the volcanoes themselves [1], and Tharsis flows are often many tens to hundreds of km in length. Further, the orientation of the dike feeding this eruptive phase (Fig. 1) is not clearly radial to any particular edifice, and its orientation and timing raise the question of magma and dike sources late in the history of the Tharsis region. Further analysis of this feature and its relation to Tharsis lava flows outside the fan-shaped deposit will assist in addressing these questions.

References: [1] L. Wilson and J. Head, JGR, 107, 10.1029/2001JE001593, 2002. [2] L. Wilson et al., LPSC 36, #1189, 2005. [3] J. Head et al., this volume, 2005. [4] B. Lucchitta, Icarus, 45, 264, 1981. [5] J. Head and D. Marchant, Geology, 31, 641, 2003. [6] D. Shean, et al., JGR, 110, doi:10.1029/2004JE002360, 2005. [7] R. Parsons and J. Head, LPSC 36, #1139, 2005. [8] A. Rubin, JGR, 97, 1839, 1992. [9] L. Mastin and D. Pollard, JGR, 13221, 1988. [10] L. Wilson and J. Head, JGR, 93, 14785, 1988. [11] L. Wilson and J. Head, JGR, 86, 2971,1981. [12] L. Wilson and J. Head, RG, 32, 221, 1994.

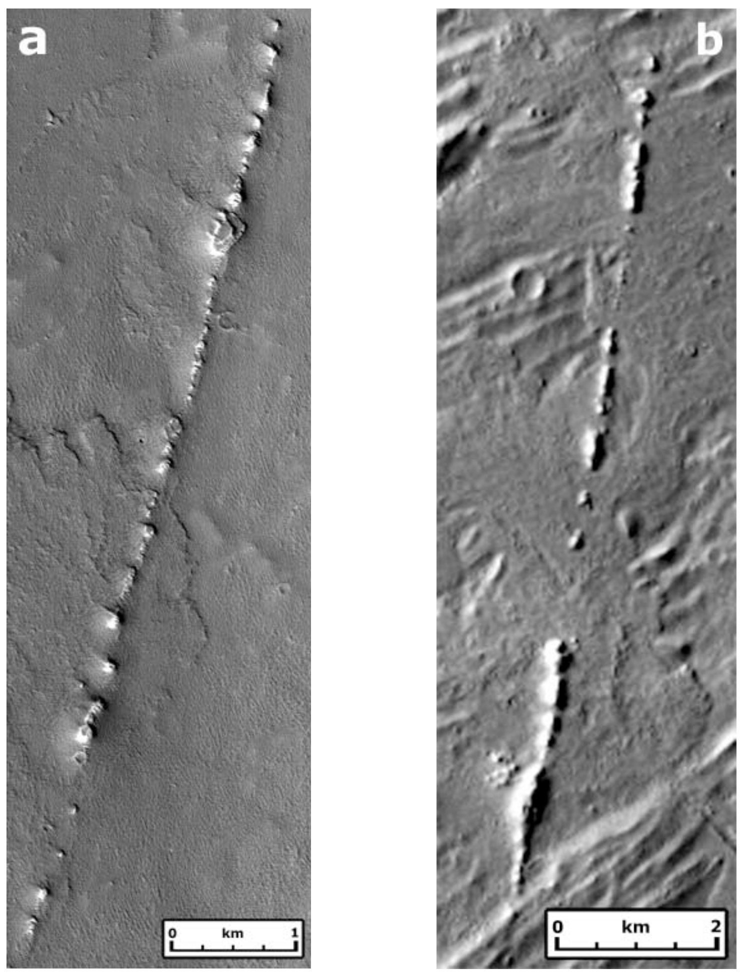

Figure 1. Rows of volcanic cones and adjacent flows superposed on the Arsia fan-shaped cold-based glacial deposit [5]. a) Southern segment (MOC image S07-01314, ~3.5 m/pxl. B) Northern segment (THEMIS image V12087009, ~35 m/pxl).