NEW EVIDENCE FOR A MAGMATIC INFLUENCE ON THE ORIGIN OF VALLES MARINERIS. J.M. Dohm[1], R.C. Anderson[2], V.R. Baker[1], K.L. Tanaka[3], T.M. Hare[3], and W.V. Boynton[1], [1]University of Arizona, Tucson, AZ, [2]Jet Propulsion Laboratory, Pasadena, CA, [3]USGS, Flagstaff, AZ, jmd@hwr.arizona.edu

Introduction: Stratigraphic, paleotectonic, paleoerosional, and geophysical information of Mars, compiled by planetary geologists through mapping investigations at global to local scales, demonstrate that magmatic-driven processes, including plume-driven tectonism, dominate the dynamic geologic history. This is best exemplified at Tharsis and the surrounding regions [e.g., 1], where five major stages of pulse-like geologic activity resulted in the formation of a magmatic complex [2-4]. The complex has been reported as a superplume [5,6] in large part based on terrestrial work [7,8].

Magmatic-driven tectonic activity associated with the growth of Tharsis resulted in volcanic constructs of diverse sizes and shapes and extensive lava flow fields [e.g., 1], large igneous plateaus [2,3,9], catastrophic outflow channels [e.g. 1,10], putative ash-flow and air-fall deposits [11], and systems of radial faults and circumferential systems of wrinkle ridges and fold belts [12] centered about local and regional centers of magmatic-driven activity [13]. One such center was mapped near the central part of Valles Marineris (listed hereafter as VM), a vast canyon system that is the most conspicuous radiating systems of structures. The central part of VM has been identified as a site of magmatic-driven activity that began during the Late Noachian (Stage 2 of Tharsis activity; see [2,3]) and may have been episodic into the Amazonian Period (Stages 4 and 5), including uplift, tectonism, intrusive activity, and volcanism [2,3,14].

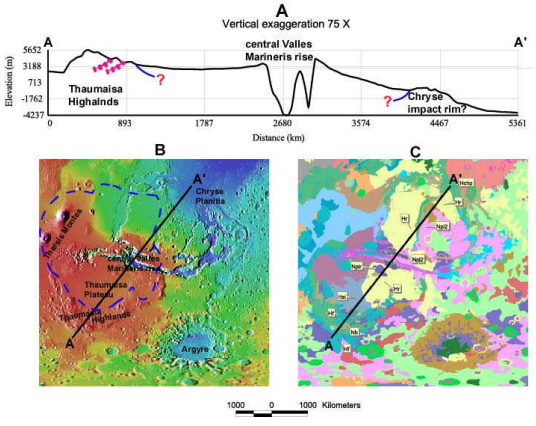

Fig.1. Based from [4], (A) Present-day MOLA profile (Transect A-A') across the west-central part of the Thaumasia highlands, the southeast part of the Noachian drainage basin (queried blue line represents uncertain basin extent), including the central VM rise (center of tectonic activity, interpreted to be the result of magmatic-driven uplift [4,13]), and materials of inferred rim of Chryse impact basin, (B) MOLA shaded relief map showing features of interest, including the central VM rise, and (C) part of the geologic map of [1].

Newly identified features: In addition to the paleotectonic signature of magmatic-driven uplift [4,10,13,15] and promontories interpreted to be associated with volcanism within VM [16-17], newly identified features support magmatic-driven activity as a major contributor to the geological evolution of the vast canyon system. For example, a >50km-diameter vent structure has been identified southwest of the Melas Chasma using THEMIS day time imagery (also see Dohm and Hare, this issue and Tanaka et al., this issue). This feature spatially registers with the Late Noachian (Stage 2) center identified by [13] (**Fig.2**).

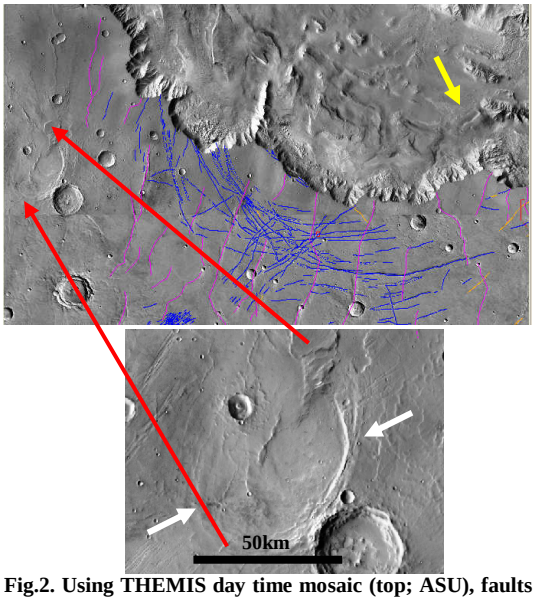

Fig.2. Using THEMIS day time mosaic (top; ASU), faults radial and concentric about Melas Chasma (blue lines), wrinkle ridges (violet lines), and the newly identified vent structure (bottom; white arrows) are highlighted. Note that the faults mark magmatic-driven activity associated in space and time with the development of the central VM rise (Fig. 1) and the vent structure. Also shown is the approximate location of Fig. 3 (yellow arrow).

Other features include structurally-controlled promontories within Melas Chasma interpreted to be volcanoes using HiRISE imagery, reminiscent of volcanic fields of northern Arizona where volcanism was

controlled by pre-existing basement structures [18,19].

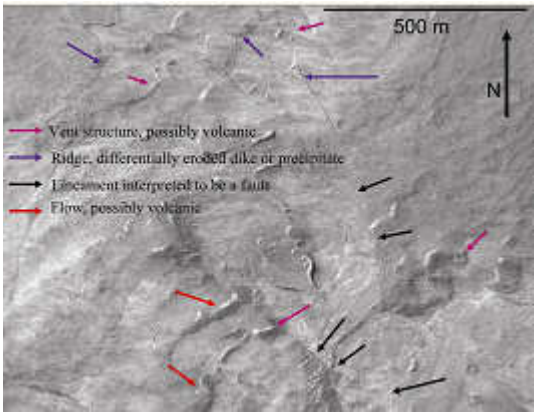

Fig. 3. Using HiRISE image TRA_000849_1675, features possibly mark magmatic-driven activity (see Fig. 2 for location within Melas). Highlighted are hills with summit depressions (possible volcanic vent structures; pink arrows), lineaments (possible faults; black arrows), flow features (possible lava flows; red arrows), and ridges (possible dikes exposed through differential erosion; violet arrows) in the southeast part of Melas, is consistent with hypothesized magmatic-driven activity of the canyon and surrounding regions [3,4,10,13-18]. These features display characteristics similar to features of Mid Miocene/Pliocene volcanic fields on Earth where basement structural control influenced the subterranean migration of magma evidenced through differentially eroded vent alignments, plugs, and dikes that display trends similar to those of fault systems [19,20]) and where differential erosion resulted in inverted topography (e.g., ponding of lavas in topographic lows that are subsequently differentially eroded to become mesas [e.g., 21]).

In addition, K/Th is distinctly higher in the central part of VM than average in other regions [22] (**Fig.5**). Possible explanations include: (1) ice-magma interactions that may have led to the elevated K/Th signal or (2) the lava flow materials are intrinsically high in K/Th and thus emphasizing the compositional heterogeneity of the Martian mantle [22].

Implications: Rifting, magma withdrawal, and tension fracturing have been proposed as possible processes involved in the initiation and development of the canyons [e.g., 16]. Lucchitta and others noted that the depth of the large troughs may have been caused by (1) collapse of near-surface materials due to withdrawal of underlying material or opening of tension fractures at depth; (2) development of keystone grabens at the crest of a bulge; or (3) failure and subsequent drifting of plates [16]. Lucchitta also recognized that many of the faults associated with VM may have been associated with volcanic activity [17]. Many of these may not be mutually exclusive in the formation of vast canyon system, as indicated by key pieces of information such as the tectonic center of activity identified by [13], the central VM rise shown by [4], the faults that are radial and concentric about Melas Chasma, the landforms interpreted to be volcanic in origin in the canyons [16-18], the newly identified vent structure that is spatially associated with the Stage 2 center defined by [13], and a distinctly higher than average K/Th signature [22]. Magmatic activity along basement structures appears to be a significant contributor to the development of VM, especially during its incipient development, which may have included Tharsis-driven plume manifestations.

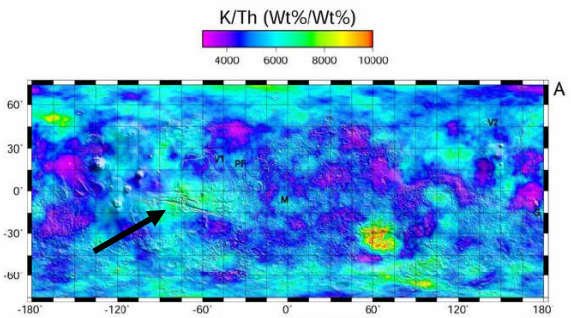

Fig 5. Based from [22], map of the variation of K/Th on Mars with the central part of VM (black arrow) being one of several regions that record elevated K/Th.

REFERENCES: [1] Scott, D.H., and Tanaka, K.L., 1986, *USGS I-Map 1802A*. [2] Dohm, J.M., and Tanaka, K.L., 1999, *Planet. & Space Sci*., *47*, 411-431. [3] Dohm J. M. et al., 2001a, *USGS I-Map 2650*. [4] Dohm, J.M., et al., 2001b, *J. Geophys. Res.*, 106, 32 943-32 958. [5] Baker, V.R., et al., 2007, *In Superplumes: beyond plate tectonics.* D.A Yuen, S. Maruyama, S-I Karato, and B.F. Windley (eds.). Springer, pgs. 507-523. [6] Dohm, J.M., et al., 2007, *In Superplumes: beyond plate tectonics.* D.A Yuen, S. Maruyama, S-I Karato, and B.F. Windley (eds.). Springer, pgs. 523-537. [7] Maruyama, S., 1994, *J. Geol. Soc. Japan* 100, 24–49. [8] Li, Z.X., et al., 2003, *Precambrian Research* 122, 85-109. [9] Frey, H., and Grant T.D., 1990, *J. Geophys. Res.*, 95, 14,249-14,263. [10] Dohm, J.M., et al., 2001c, *J. Geophys. Res.*, 106, 12,301-12,314. [11] Malin, M.C., 1979. *NASA Conf. Pub.* 2072, 54. [12] Schultz, R.A., Tanaka, K.L., 1994, *J. Geophys. Res.*, 99, 8371-8385. [13] Anderson R.C., et al., 2001, *J. Geophys. Res.*, 106, 20,563-20,585. [14] Williams, Jean-Pierre, et al., 2003, *Geophys. Res. Lett.*, *30*, doi :10.1029/2003gl017662. [15] Scott, D.H., and Dohm, J.M., 1990, *MEVTV Workshop "Evolution on Magma Bodies on Mars"*, 39-40. [16] Lucchitta, B.K., et al., 1992, in *Mars*, pp. 453-492, Univ. of Ariz. Press, Tucson. [17] Lucchitta, B.K., 1990, *Icarus*, 86, 476-509. [18] Komatsu, Goro, et al., 2004, *Geology*, 32, 325-328. [19] Shoemaker, E.M., et al., 1978, *GSA Memoir* 152, 341- 367. [20] Dohm, J.M., 1995, *Thesis*, Northern Arizona University, Flagstaff, Arizona, pp. 101. [21] Holm, R.F., 2001, *GSA Bull.*, 113, 1467-1485. [22] Taylor, G.J., et al., 2006, J. Geophys. Res., 111, E03S06, doi:10.1029/2006JE002676.