DISTINGUISHING VOLCANIC AND FLUVIAL ACTIVITY IN MANGALA VALLES, MARS VIA GEOMORPHIC MAPPING.

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Introduction: Mangala Valles is a 900 km-long outflow system extending from the martian southern highlands toward the northern lowlands just west of the Tharsis rise. Until recently, it was widely accepted that the flow features observed in Mangala Valles were the result of one or more catastrophic flooding events, likely by igneous disturbance of massive aquifer sources [1,2,4]. Such ideas have been supported by the presence of obvious streamlined features that can be easily identified using relatively low-resolution images such as those returned by Viking [1]. Subsequent studies focused on the number of flooding events, the amount of time separating each event, whether they shared a common source, and whether intermittent volcanism took place between flooding events [e.g., 1,3,4]. Recently, Leverington [5,6] introduced the idea that the system could have been carved solely by thermo-mechanical erosion by voluminous lava flows, or a hybrid hypothesis where the valley was initially carved by aqueous processes and later modified by volcanic erosion and deposition.

McEwen et al. [10] also suggested that rather than being a strictly fluvial or strictly volcanic system, Mangala Valles was formed by fluvial incision followed by large-scale volcanic activity. To investigate this hypothesis, we composed a detailed geomorphic map of the Mangala Valles area using primarily MRO CTX images [9] and evaluated age estimates calculated using crater counting methods [16]. Although Mangala Valles has been previously mapped [1,3,4,17], CTX images provide resolution and coverage not available to previous authors, who relied on HRSC, MOC, MOLA, and Viking imagery for map production and analysis. Consequently, these maps either focus on a very small area or lack sufficient detail to make complete interpretations of the area as a whole.

Methods: Our mapping area extends from approximately 3.5°S to 20°S and 146°W to 157°W. Digital mapping was performed using a THEMIS daytime infrared image mosaic (spatial resolution ~100 m/px) as a base [12]. Individual CTX images were heavily used for detailed mapping and analysis due to their relatively high resolution (~6 m/px), near-ideal illumination conditions (~3 PM), and excellent coverage of the mapping area. MRO HiRISE images (spatial resolution 0.3 m/px) [15] were also used, though to a lesser extent than CTX as they have very limited coverage of the study area. MOLA data [11], used in the forms of contours, elevation cross sections, and colorized elevation maps, were crucial for identification of unit contacts and other detailed analyses. Similarly, HRSC digital terrain (DTMs; spatial resolution ≥12.5 m/px) [18] were useful in determining elevation differentials for geologic mapping. Geologic maps from previous work [1,3,4,17] were used as reference. JMars [14] was used as the mapping and crater counting tool as well as the primary source of geographic information. Craterstats 2 [16] was used to model crater retention ages.

Discussion: In Figure 1 we present our complete geomorphic map of the whole study area, which depicts the entire Mangala region and the 19 units mapped. Within the valley, four of these units (ASt, ATs, AGs, ALk) exhibit morphologic characteristics diagnostic of extensive fluvial modification of bedrock (including several units with Channeled Scablands-type morphology) and four other units ("smooth plains" units: ASp1, ASp2, ASp3, and ASp4) exhibit morphologic characteristics suggestive of a more recent volcanic origin. Fluvial modification surfaces are less extensive to nonexistent within smooth plains units. Models of crater counts performed at 32 locations throughout the area suggest higher crater retention ages (~750 Ma, unit ASt) on surfaces with extensive fluvial modification and relatively low crater retention ages (~300–650 Ma) on the smooth plains surfaces. Note that these crater retention ages may be much younger than the initial landscapes produced by fluvial or volcanic activity due to extensive eolian modification. Therefore, the ages derived in this study are treated as relative.

Conclusion: The occurrence of scoured bedrock stratigraphically below all other observed geomorphologies within the valles, in addition to evidence provided by crater retention ages, suggests that fluvial activity preceded the deposition of the volcanically-derived units. However, fluvial modification features identified on some of the relatively young smooth plains surfaces indicates that aqueous bedrock abrasion additionally took place following the deposition of volcanic material in the valley, yet prior to emplacement of the youngest unmodified lava flows. This is consistent with a geologic history consisting of recurrent phases of valley flooding alternating with or in concert with phases of volcanic activity in the valles. Such repeated episodic behavior may indicate continual aquifer and magma chamber replenishment during an extended period of time within the subsurface of the Mangala Valles region. Detailed studies of similar fluvo–volcanic outflow systems, such as Athabasca Valles [7] and Kasei Valles [8], may provide insight into the recurring, and perhaps coupled, nature of these processes on Mars.

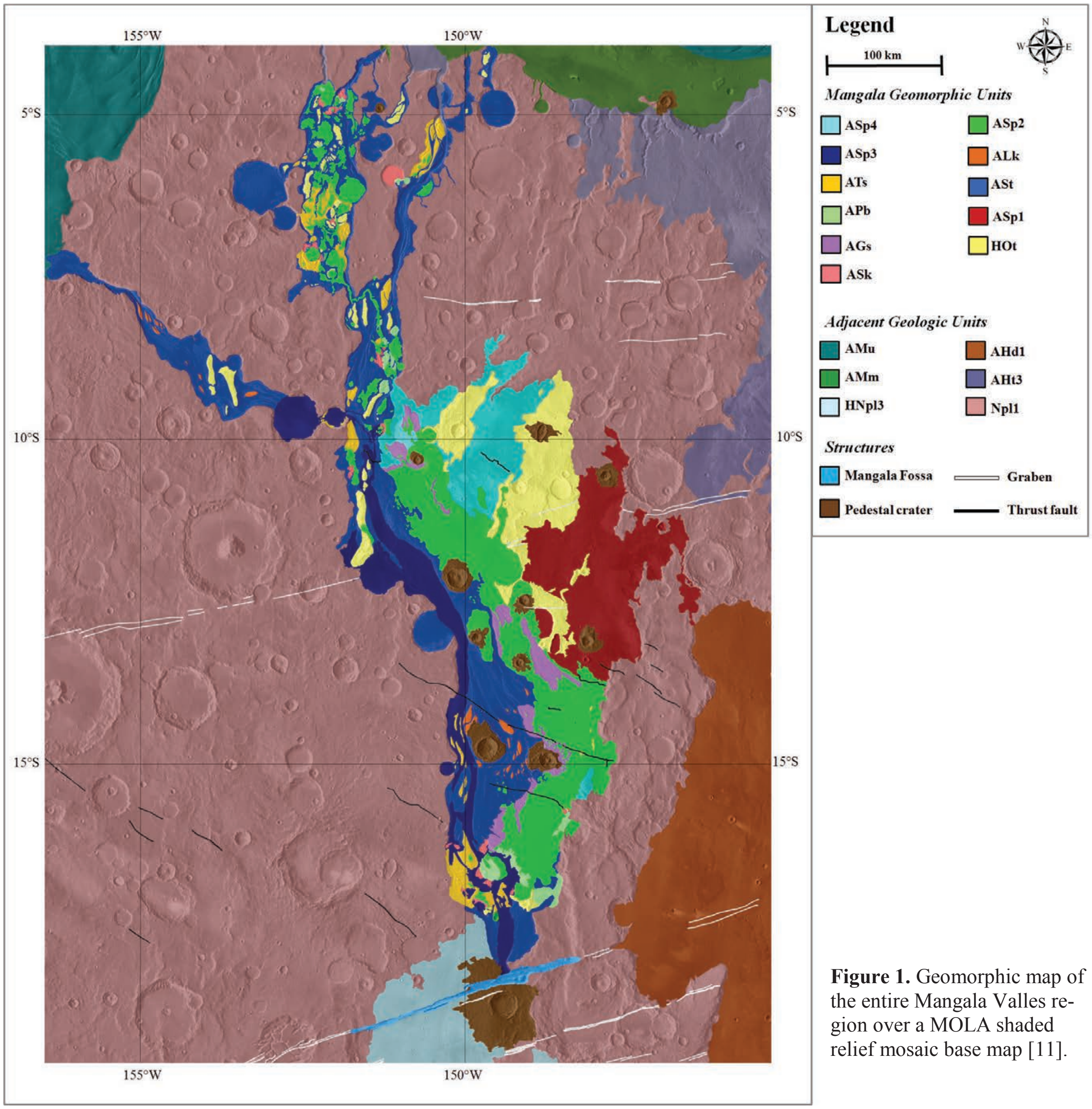

Figure 1. Geomorphic map of the entire Mangala Valles region over a MOLA shaded relief mosaic base map [11].

References: [1] Tanaka L. T. and Chapman M. G. (1990) *J. Geophys. Res.,* 95, B9, 14,315–14,323. [2] Zimbelman J. R. et al. (1992) *JGR*, 97, E11, 18,309–18,317. [3] Basilevsky A. T. et al. (2008) *Planet. Space Sci.,* 57, 917–943. [4] Ghatan G. J. et al. (2005) *EMP*, 96, 1–57. [5] Leverington D. W. (2011) *Geomorph.* 132, 51–75. [6] Leverington D. W. (2007) *JGR*, 112, E11. [7] Jaeger W. L. et al. (2010) *Icarus*, 205, 1, 230–243. [8] Chapman M. G. et al. (2010) *EPSL*, 294, 256–271. [9] Malin M. C. et al. (2007) *JGR*, 112, E5. [10] McEwen A. S. et al. (2012) *LPSC 2012*. [11] Smith D. E. et al. (2001) *JGR*, 106, E10, 23,689–23,722. [12] Christensen P. R. et al. (2004) *Space Sci. Rev.*, 110, 85–130. [13] Christensen P. R. et al. (2003) *Science*, 300, 5628, 2056–2061. [14] Christensen P. R. et al. (2009) *AGU 2009*. [15] McEwen A. S. et al. (2007) *JGR*, 112, 5. [16] Michael G. G. and Neukum G. (2010) *EPSL,* 294, 223–229. [17] Chapman M. G. et al. (1989) *USGS*. [18] Jaumann R. et al. (2007) *Planet. Space Sci.*, 55(7–8), 928–952.