MAJA VALLES: A MULTI-SOURCE FLUVIO-VOLCANIC OUTFLOW CHANNEL SYSTEM. A. L. Keske and P. R. Christensen, School of Earth and Space Exploration, Arizona State University, Tempe AZ, 85281 (alkeske@asu.edu).

Introduction: The mechanism of formation of martian outflow channels has been a subject of ongoing debate. Their geomorphic resemblance to the channeled scablands of the Pacific Northwest has led to the general belief that these features were eroded by large-scale aqueous flooding [1]. However, the observation that many of these channels, such as Athabasca Valles, are coated in lava issuing from the same source as the interpreted water source [2] has motivated the alternative hypothesis that these channels were instead carved by fluid, turbulent lava [3].

Study area and previous work: Maja Valles is a 1200-km long outflow system to the north of Vallis Marineris and south of the Kasei Valles outflow system that divides the smooth volcanic plains of Lunae Planum to the west from the older Xanthe Terra highlands to the east. It heads at Juventae Chasma, part of the Vallis Marineris system, extends toward the north, and curves toward the northeast before debouching onto Chryse Planitia (Fig. 1). The system was first described by Sharp and Malin (1975) and mapped by Baker and Kochel (1979) using images from Viking [6], who along with later authors [7,8,9] placed its origin in the late Hesperian on the basis of impact crater population densities derived from Viking imagery. However, recent evidence of crater density variations within the Maja Valles system derived using images from the Mars Orbiter Camera (MOC) [10] [11] suggests that the formation history of Maja Valles may involve multiple resurfacing events that have greatly influenced the large-scale topography of the region.

Observations and interpretations: The objective of this study is to determine the relationship between volcanic and fluvial processes in the Maja Valles region using key observations as seen from images and digital terrain models produced from the High Resolution Science Experiment (HiRISE) [12] and the Context Camera (CTX) [13] aboard the Mars Reconnaissance Orbiter, which provide a spatial resolution and coverage not available to previous authors. As noted by previous works, Maja Valles host a suite of standard fluvial landforms. However, we have also found that the northern portion of the valles is thinly coated with lava, the individual flows of which are difficult to trace. The lava has buried much of the older channel landforms and overprinted it with effusive flow features, including polygons and bathtub rings (Fig. 2c, d). Additionally, within these flows are patches of dark, relatively pristine material pasted onto adjacent crater pedestals and streamlined islands (Fig. 2e–g). Their relative brightness in THEMIS Night IR [14] indicates that they are likely composed of coherent, rocky material. Digital Terrain Models derived from HiRISE and CTX stereo pairs reveal that the patches themselves are flat with edges locally occurring at a single elevation, suggesting that they are pools that have collected in local topographic lows. We have found this both within Maja Valles as well as to the west of the channel system (Fig. 1), though many of those outside of the valles are less pristine in appearance, and are thus probably older. We have interpreted these as ponds of lava that remain from one or more fluid lava flows that flooded the channel system and receded as it drained, leaving marks of the local lava high stand.

Despite the presence of fluvial landforms throughout the system, lava flow features are present only in the northern portion of the system. However, they continue parallel to the west channel system, where they can be traced to a collection of vents just north of Vallis Marineris.

Implications: It is not uncommon to find evidence of effusive volcanism playing a major role in the history of martian outflow channels [e.g., 2,15,16]. However, in previously studied cases, the source of the volcanic activity and fluvial activity have been indistinguishable, leading to speculation that the features may have been produced by the same mechanism (i.e., turbulently flowing lava). Maja Valles provides evidence to the contrary: there are numerous fluvio-volcanic features within the channel bearing similarity to those seen in outflow channels such as Athabasca Valles, yet the source of volcanism is distinct from the source of the channels. Furthermore, since there are no channels between the source of the lava flows and their intersection with the channels of Maja Valles, it is clear that despite evidence suggesting that the lava flows were very fluid, they did not achieve the turbulence necessary to thermomechanically erode large channels. These findings thus weaken arguments that lava erosion may have played a major role in the formation of martian outflow channels in general.

Although the volcanic and fluvial features in Maja Valles were derived from separate sources, these sources are both located along a chain of tectonic features part of the Vallis Marineris system. It is therefore likely that they are expressions of a common volcano-tectonic system occurring as a result of Tharsis activity, contributing to current ideas about the relationship between outflow channels and the thermal evolution of the Tharsis system as a whole during the Amazonian.

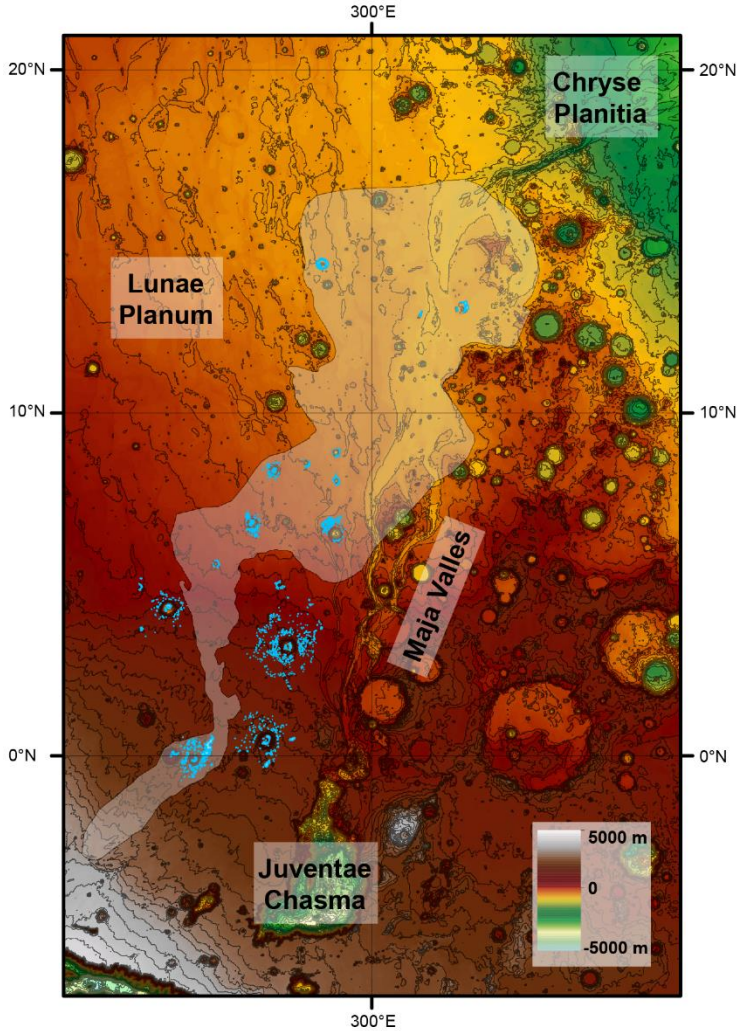

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Fig. 1 (left). MOLA [17] topographic map of the study area with lava pools shown in blue and the most likely route taken by the youngest lava flows shown in light gray (mapped using THEMIS Night IR). Contour interval 100m.

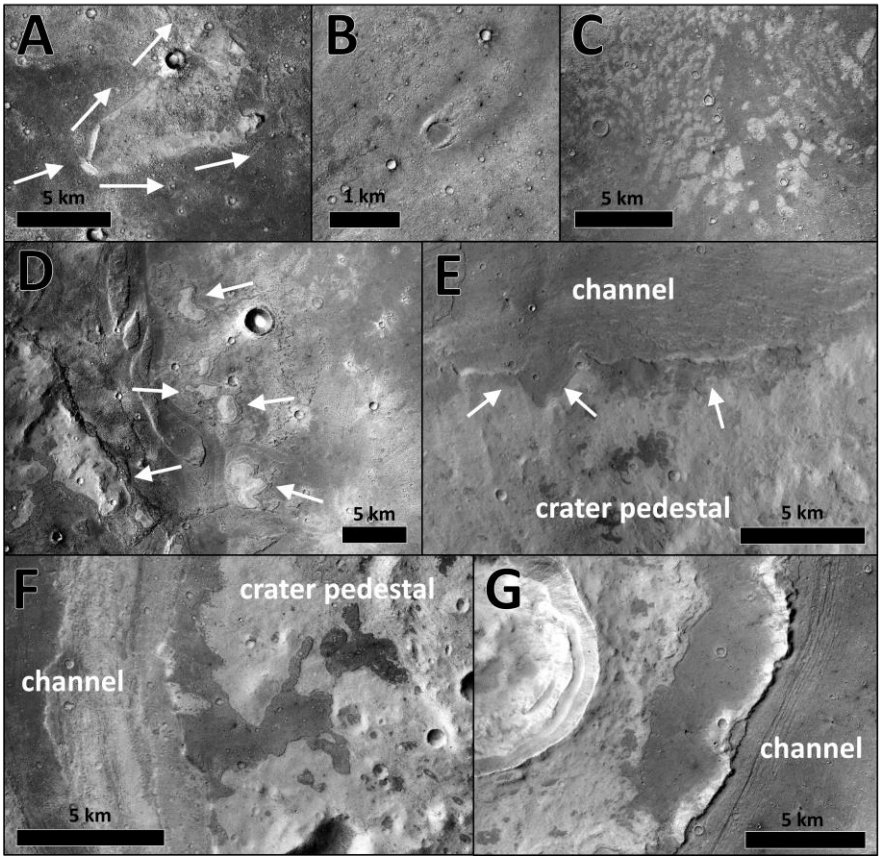

Fig. 2 (right). Examples of volcanic features identified in Maja Valles. A) A wake in a lava flow caused by an elongate obstacle (flow direction indicated by white arrows). B) A pre-existing streamlined island that has been buried by younger lava. C) Polygons created by broken up cooled crust on the surface of a flow. D) Bathtub rings (indicated by white arrows) showing the lava high stand. E) The edge of a crater pedestal over which lava has breached and subsequently drained, leaving a mark of its high stand (indicated by arrows). F, G) Examples of dark pools perched on topographic highs throughout the valles. All images CTX.