ORIGIN AND EVOLUTION OF VALLEYS ON MARTIAN VOLCANOES: THE HAWAIIAN ANALOG; V.C. Gulick and V.R. Baker, Department of Geosciences, University of Arizona, Tucson, Arizona 85721

Since their discovery in the early 1970's, valleys and channels on the Martian volcanoes have not received the attention given to studies of the outflow channels and other valleys on the heavily cratered terrain. Past studies have focused on the suggestion and interpretation of possible valley origins. For the valleys/channels on Alba Patera, Milton [1] suggested a fluvial origin based on a single high resolution Mariner 9 picture while Carr et al [2] suggested an origin by lava tube and channel formation based on Viking imagery. For the valleys on Ceraunius Tholus, Sharp and Malin [3] suggested a fluvial origin. In 1979 Reimers and Komar [4] added that the valleys on Ceraunius Tholus and Hecates Tholus were not formed by lava erosion, lava tube collapse or tectonic fracturing. This research attempts to study the origin and evolution of valley and channel forms on six Martian volcanoes: Ceraunius Tholus, Hecates Tholus, Alba Patera, Apollinaris Patera, Hadriaca Patera, and Tyrrhena Patera.

Photo interpretive and mapping studies of valleys and channels indicate formation by fluvial and/or lava processes. Lava tubes and channels form distributary patterns and have discontinuous, irregular surface morphologies in contrast to fluvial valleys which are continuous and form tributaries. Many lava channels are pitted suggesting a formation by lava tube collapse, while a few display levees and are considered constructional landforms.

Valley and channel morphologic features on the volcanoes are evaluated for their compatibility with fluvial, lava, sapping, and volcanic density flow origins. Results indicate that most valleys on Ceraunius, Hecates, and Alba are fluvial, while valleys on Tyrrhena, Hadriaca, and Apollinaris are of mixed lava and fluvial origin. Less than one-third of the valleys on Ceraunius, Hecates, and Tyrrhena and less than two-thirds of the valleys/channels on Alba have morphologic features which are suggestive of a lava origin. Greater than two-thirds of the valleys on Apollinaris and Hadriaca display lava-associated features.

Fluvial valleys on Alba are finely-textured, well-integrated and are parallel to pseudo-dendritic in form (Figure 1). These valleys, located on the northern flank, are less defined than the lava channels and form in regions where lava flow morphology is subdued.

Ceraunius contains two distinct classes of continuous radial valleys: 1) defined, fresher appearing valleys with steep walls and 2) less defined, more degraded appearing valleys with eroded walls. Both valley types contain tributary source regions. Many of the degraded valleys are better defined and are fresher appearing toward their distal reaches. Conversely, several defined valleys have degraded headwater regions.

Hecates, in comparison to Ceraunius, has better defined and integrated parallel valley systems. Most valleys have numerous tributaries. Hecates also shows evidence of having attained a more advanced stage of valley development. On its western flank, enlargement of distal valley reaches suggests modification by sapping processes. Large fan deposits which are prominent at the mouths of these valleys indicate extensive sediment transport and deposition.

Geomorphometric studies of Ceraunius, Hecates, and Alba indicate that valley junction angles and valley magnitudes increase with decreasing slope

(Table 1). Drainage densities are variable probably due to complex interactions of changes in stream process and slope.

Similarities between Martian and Hawaiian volcano valley development include: 1) initiation by surface runoff; 2) subsequent enlargement by groundwater sapping, and 3) eventual stabilization as groundwater systems become less energetic. Additionally, ash mantling, which is critical to the initiation of drainages on the island of Hawaii, may also explain why fluvial valleys are present on some Martian volcanoes but not on others of the same age.

Conclusions of this study are: 1) that most valleys/channels on the Martian volcanoes have a fluvial and/or lava origin; 2) that Martian volcano valleys have an evolution similar to Hawaiian valleys; and 3) that ash mantling may have been critical to the initiation of drainages on the Martian volcanoes as it has been to valleys on Mauna Kea and Kohala in Hawaii.

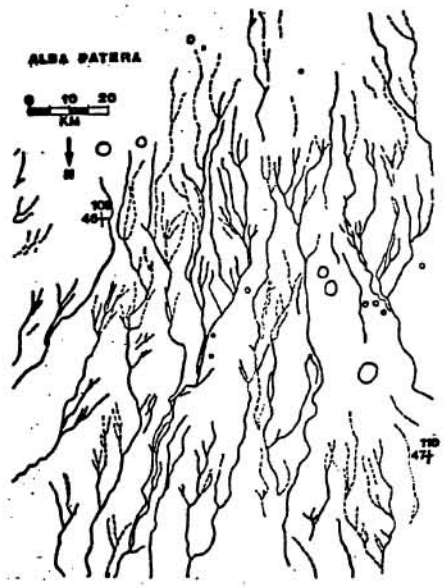

Figure 1. Fluvial valleys on Alba Patera.

Table 1. Morphometry of Valleys/Channels on Martian Volcanoes.

Volcano	Average Slope*	Drainage Density (km/km^2)	Magnitude	Junction Angle** θ1	θ2	θ1+θ2
Ceraunius Tholus	10-12°	0.5-1.1	5+	29	2	28
Hecates Tholus	3-5°	0.6-2.3	10+	25	7	33
Alba Patera	<1°	0.3-1.1	34+	33	7	41

*[4]
**θ1, θ2, and θ1+θ2 are mean values

References:
[1] Milton, D.J., 1973, JGR, 78, p. 4037-4047.
[2] Carr, M.H. et al, 1977, JGR, 82, p. 3985-4015.
[3] Sharp, R.P., and Malin, M.C., 1975, GSA Bull., 86, p. 593-609.
[4] Reimers, C.E., and Komar, P.D., 1979, Icarus, 39, p. 88-110.