REFINED VOLCANIC AND TECTONIC HISTORY OF THE VALLES MARINERIS, MARS; D. John Chadwick, Gregory J. Leonard, and Kenneth L. Tanaka; U.S. Geological Survey, Flagstaff, AZ 86001

The early formational history of the Valles Marineris must be largely deduced from the crosscutting relations of structures to surrounding plateau materials that can be dated, because mass wasting within the chasmata has erased craters that could have been used to determine relative ages. Previous crater counts [1] were not comprehensive, not taking full advantage of areas available for counting. We have performed more complete crater counts, based on the mapping of [1], for all larger units surrounding the Valles Marineris (Figure 1). These counts (Table 1) were made from the Mars Digital Image Mosaic (at a resolution of 231 m/pixel). We counted all craters larger than 2 km in diameter; however, our relative ages are based on densities of craters larger than 5 km because of their better preservation. Our results indicate extensive formation of smooth lava plains during the Late Noachian and Early Hesperian that waned in the Late Hesperian. Following wrinkle-ridge development, Valles Marineris faulting began in the later part of the Early Hesperian and continued into the Late Hesperian. Pit and trough formation primarily occurred during the Late Hesperian, at about the same time as the formation of the outflow channels that adjoin the Valles Marineris [1]. A brief history of the region follows.

Late Noachian: The oldest units adjacent to the Valles Marineris were probably flood basalts (units Q, P, and N, Figure 1), which were later deformed in places by grabens of several orientations that generally do not parallel the chasmata.

Early Hesperian: Flood basalts continued to be emplaced, embaying and partly burying the Noachian units. Wrinkle ridges then deformed the Noachian and Hesperian plains units, except for units E and F, where wrinkle ridges either did not form or were buried by later Lower Hesperian units. In later Late Hesperian time, faults and grabens began to form that are parallel to the present chasmata (in units E, F, and N), perhaps signalling incipient formation of the chasmata.

Late Hesperian: Emplacement of smooth plains units continued, though confined to the western part of the map area and locally near the chasmata. Note the progressive decrease in age from unit Q to J to B, suggesting either a waning of Tharsis-centered volcanism or a shift in source region with time. Faulting parallel to the Valles Marineris continued, perhaps more intensely than in the Early Hesperian. Pit crater chains and catenae, possibly indicative of the onset of collapse in the Valles Marineris, first appeared in the Late Hesperian. No partly buried catenae are visible in Upper Hesperian plains units, and catenae are developed equally well in Upper and Lower Hesperian units. Mass wasting of the chasmata walls, collapse, and minor tectonism probably continued into the Amazonian.

The appearance of grabens and faults that parallel the Valles Marineris in the Early Hesperian suggests that the chasmata began to develop at this time, but the apparent greater number of grabens and faults and the onset of catenae formation in the Late Hesperian suggest that most of the tectonism and collapse in the Valles Marineris took place in the Late Hesperian.

Reference: [1] Witbeck et al., 1991 USGS Map I-2010.

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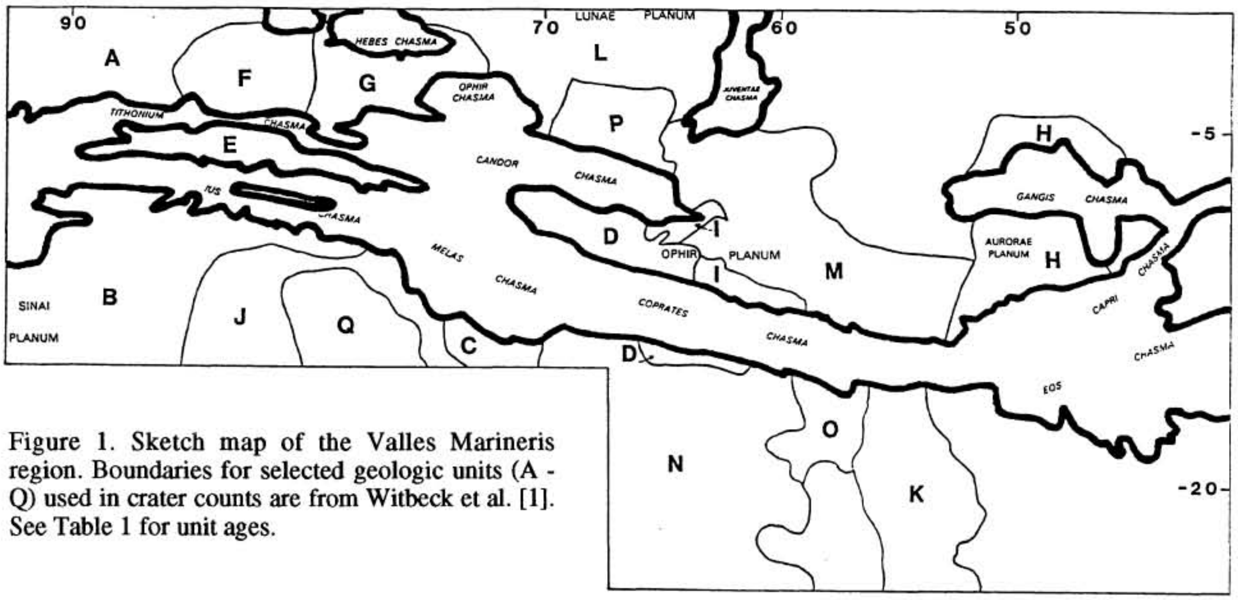

Figure 1. Sketch map of the Valles Marineris region. Boundaries for selected geologic units (A - Q) used in crater counts are from Witbeck et al. [1]. See Table 1 for unit ages.

Table 1. Cumulative crater densities and relative ages of geologic units in the Valles Marineris region of Mars.

Geologic unit[1]	Symbol	Crater density[2] N(5)	Area (km^2)	Possible age range[3]	Likely age[4]
		Syria Planum Formation			
Upper member	Hsu				
A		86±31	92,624	UH/LA	UH
B		119±32	117,342	LH/UH	UH
		Plateau units			
Younger fractured material	Hf				
C		71±50	28,085	UH/MA	UH
D		106±40	66,029	LH/LA	UH
E		153±48	65,223	UN/UH	LH
F		164±47	73,069	UN/UH	LH
Smooth unit	Hpl_3				
G		110±39	72,568	LH/UH	UH
H		273±54	95,221	UN	UN
I		332±105	30,079	MN/UN	UN
Ridged plains material	Hr				
J		155±40	96,860	LH/UH	LH
K		147±43	81,381	LH/UH	LH
L		163±31	165,404	LH	LH
M		190±31	200,091	UN/LH	LH
N		218±34	183,864	UN/LH	UN
Subdued cratered unit	Npl_2				
O		122±55	40,846	LH/UH	UH
P		210±63	52,405	UN/LH	UN
Ridged unit	Nplr				
Q		234±57	72,800	UN/LH	UN

[1]Units from Witbeck et al. (1991). [2]Number of craters larger than 5 km in diameter per million square kilometers. [3]Based on Tanaka (1986); reflects both material and modification ages. A = Amazonian, H = Hesperian, N = Noachian; U = Upper, M = Middle, L = Lower. [4]Based on crater densities and superposition relations.