MARTIAN OUTFLOW CHANNELS: LOW GRADIENTS AND PONDED FLOW, B. K. Lucchitta and H. M. Ferguson, U.S. Geological Survey, Flagstaff, AZ 86001.

Erosive power and sediment transport of flood waters in martian outflow channels depend to a large extent on gradients on channel floors. Past estimates of these capabilities [1,2,3] were based on slopes derived from the U.S. Geological Survey's topographic map [4]. Recent radar observations of Mars made by the Goldstone facility (1971-1980) [5,6] indicate gradients on the channel floors in the Chryse basin that are much lower than gradients obtained from the topographic map. The new gradients will severely affect calculations of the hydraulics of floods and many of the former estimates will have to be revised.

In this report we analyzed radar tracks across Lunae Planum and the Chryse basin channels. The study included six radar elevation profiles between lat 21° and 23° N., eight profiles between lat 9.5° and 11.5° N., six profiles between lat 3° and 6° S., and six profiles between lat 14° and 15° S. Profiles that occur within one to two degrees of latitude of each other were superposed and average elevations obtained by inspection. Our method appears valid because our averaged values of elevation coincide with those obtained statistically by Downs et al. [7] for a few segments of radar track. Furthermore, in plains areas, we found that elevation points from different profiles lie, commonly, within 100 m of one another. In rough areas like channels, the points are more scattered. Nevertheless, representative elevations can be obtained from clustered points, and low elevations from minima. Single low points that were several hundred meters deeper than all other points were discarded as unreliable. From the elevations derived from radar altimetry we established longitudinal profiles for the channel floors. Since Roth et al. [6] argued that most minima in rough terrain reflect real elevation values, we compiled two profiles, one based on average elevation values, the other on minima.

Our results show that the gradients of martian outflow channels are extremely low; indeed, some channel floors are level, or rise gently towards the north against the presumed flow direction (Table I). The gradients are steeper and the morphology is different for Maja and Ares Valles than for Tiu and Simud Valles. Maja and Ares Valles are locally bounded by terraced scarps and generally lie less than 1 km below the adjacent terrain; they have abundant, narrow, streamlined islands on their floors. By contrast, the banks of Simud and Tiu Valles have sharp, steep scarps. The scarps decrease in height northward, from 5 km near the chaotic terrains to 1 km near the Chryse basin. Simud and Tiu Valles are interrupted by many areas of chaotic terrain containing angular mesas. These valleys are essentially level, perhaps rising slightly with average gradients of at most 0.3 m/km. Whereas the gradients of Maja (2.5 m/km) and Ares (1.1 m/km) Valles are within the same order of magnitude as gradients of the catastrophic flood channels in the scablands of Washington State (1.0 m/km to 4.0 m/km [8]), the gradients of Simud and Tiu Valles are an order of magnitude lower. Some explanation for this anomaly must be found.

Uphill gradients were explained by Masursky et al. [8] as the result of post-channel warping. Tectonic activity was also advocated by Roth et al. [6] as the cause of a trough whose floor is -8 km in elevation in the southern part of Eos Chasma. Even though a regional southward tilt of Lunae Planum and the channel region could have reversed channel floor gradients, such tectonism cannot be verified. We consider it a weak hypothesis. We also believe it unlikely that reversed gradients are caused by local warps, because the near level or slightly reversed slopes occur over the entire length of Simud and Tiu Valles. In addition, warping is not apparent in the adjacent Maja and Ares Valles, whose gradients do not reverse, or on the highland plateaus that form the channel rims; elevations of the rims gradually decrease from 3 km north of Eos Chasma to 1.5 km at the outlet of Capri Chasma to -1 km at lat 10° N.

If post-channel warping did not cause the level or reversed slopes in Simud and Tiu Valles, how could water that was released from the Valles Marineris have made its way through these channels to the northern plains? The answer may be ponding. Water may have pooled in hollows along the northward path. The lows may be grabens in the Valles Marineris, or depressions associated with ancient craters in the chaotic terrains. Loss of ground ice [9] may have contributed to the formation of depressions. In Eos Chasma, water [10] may have reached the 1.2 km level, the elevation of sedimentary deposits of intra-chasma plateaus. Release of a pond that deep would have permitted overflow of obstacles in the channel path downstream. Circular depressions in the chaotic terrain through which the channels made their way, may have become filled

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with water or perhaps mudflow slurries of rock and ice. Water or mud slurries apparently also pooled in low areas in Candor Chasma of the Valles Marineris grabens and formed level surfaces that are traversed by numerous cracks, similar to the cracks visible in the chaotic terrain [11]. The similarity supports that chaotic terrains may form as a result of ponded fluids. Furthermore, overflow channel features seen on plateaus high above the level of chasma floors support the hypothesis that water may have reached high surface levels within the chasmata.

If the fluid in the channels ponded in local depressions to create pools of water or mixtures of water, ice, and sediments, several possibilities emerge for the formation of channel sections downstream from ponds. Overflow, headward erosion, and breaching of interfluves may have caused the postulated gigantic floods [1] or mudflows [12]. If these flows were highly charged with ice [13], locally forming masses similar to glaciers, they could have further deepened the channel floors by intensive scouring.

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Table 1. Elevations and Gradients on Channel Floors

	Lat,Long(W)	Elev. 1/ (km)	Distance 2/ (km)	Gradient 2/ (m/km)	Degrees
Ares	+10, 25	-1.4			
	+22, 31	A 3/ -1.8	890	-0.5 4/	-0.03 4/
		L-2.4		-1.1	-0.06
Tiu	-6.5, 36	A-2.5			
		L-2.7			
	+10, 33	A-2.3	1050	+0.2	+0.01
		L-2.8		-0.1	-0.01
	+21.5, 40	A-1.9	830	+0.5	+0.03
		L-2.7		+0.1	+0.01
Simud	-15, 45	A-2.5			
		L-3.5			
	-6.5, 36	A-2.5	760	0.0	0.00
		L-2.7		+1.1	+0.06
	+10, 36	A-2.5	1040	0.0	0.00
		L-2.9		-0.2	-0.01
	+21.5, 40	A-1.9	760	+0.8	+0.05
		L-2.7		+0.3	+0.02
Maja	+10.5, 59	A+1.0			
		L+0.5			
	21.5, 48	A-1.5	960	-2.6	-0.15
		L-1.9		-2.5	-0.14

1/ elevations referenced to surface of 6.1 mbar atmospheric pressure [7].
2/ measured from preceding point.
3/ A, Average elevation points on profiles
L, Minimum elevation points on profiles.
4/ Negative values indicate downhill slopes toward the north, positive values uphill slopes.

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