CONSTRAINTS ON OVERLAND FLUID TRANSPORT THROUGH MARTIAN VALLEY NETWORKS.

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Introduction: Since their discovery in Mariner 9 images [1,2], "runoff channels" [3], or more properly, "martian valley networks" [4,5] have been almost universally cited as the best evidence that Mars once maintained an environment capable of supporting the flow of liquid water across its surface. Unlike "outflow channels," that appear to indicate brief, catastrophic releases of fluid from very localized sources, valley networks often display arborescent patterns, sinuosity and occasionally meandering patterns that imply processes of overland flow: drainage basin development and sustained surficial transport of fluid. As part of the on-going Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) imaging activities, many observations of valley networks have been planned and executed; the results of some of these observations have been previously reported [6,7]. Here we provide a few cautionary notes regarding generalizations that have been made about the martian hydrosphere based on Mariner, Viking, and some MGS results.

Sustained Flow: Since its "release" at a budget press conference by Vice President Gore in February 1998, Figure 1 (a view of Nanedi Vallis) has become the most often shown MOC image, evoking as it does visions of a meandering martian river valley. Within the image is, arguably, the best evidence found of sustained fluid flow on Mars—the small, inner channel seen at the north (top) end of the image. However, little additional evidence has been found of this inner channel in any of the branches of Nanedi. Although the canyon floor is covered by wind-blown sediment, this sediment is not sufficiently thick to completely mantle all but the single exposure of the inner channel. The absence of attendant features (such as inner benches or terraces) in any of the other reaches of Nanedi further differentiates this reach from any other in the system.

Inner channels within other valley networks are *extremely* rare. In over a thousand images of networks, only one other reach of one other valley (Figure 2) shows an inner channel. The valley that most visually resembles Nanedi, (displaying, *e.g.*, a pattern reminiscent of large-scale meanders) is Nirgal; the image of the inner channel is of a reach within Nirgal. Two features are seen interior to the walls of Nirgal: paired, broad terraces extending from the walls toward the center of the valley and defining a broad, flat-floored channel between them, and a smaller, sharply defined interior channel with what appear to be raised, leeved banks.

The evidence for sustained flow in Nirgal and Nanedi, and its virtual absence everywhere else, suggests that sustained flow, even within the constrained context of the centripetal drainage pattern of Nanedi, was extremely rare on Mars during the timescale represented by the present surface expressions of valley networks.

Flow Integration: Arguably the best example found on Mars of an arborescent network are the Warrego Valles. Earlier Viking data, and now MGS images, raise serious questions concerning the interpretation of these valleys as surficial drainage. First, the valleys are not "through-going," but rather consist of transecting, elongate, occasionally isolated depressions. Second, mass movements appear to have played a role in both extending and widening the valleys. Third, the valley walls are extremely subdued, reflecting either mantling or an origin by collapse. These attributes suggest that collapse may have played the dominant role in formation of valley networks

Discussion: Groundwater follows topographic gradients nearly as effectively as surface water. The principal issue is whether the apparent contributory pattern of surficial water can be produced solely by groundwater, or if groundwater processes must mimic preexisting tributary patterns. If the former is possible, then martian valley networks may require little if any surficial flow. Even if it is not, the relationships seen in MOC data suggest that few, if any, surfaces preserve the evidence of surface fluid flow: these features may have been removed or buried. An intriguing possibility is that most valley networks are being exhumed.

References: [1] McCauley, J. F. *et al.,* (1972) *Icarus, 17*, 289-327. [2] Milton, D. J. (1973) *JGR, 78*, 4037-4047. [3] Sharp, R. P. and Malin, M. C. (1975) *GSA Bull., 86*, 593-609. [4] Pieri, D. C. (1980), *Science, 210*, 895-897. [5] Mars Channel Working Group. (1983) *GSA Bull.*, *94,* 1035-1054. [6] Malin, M. C. and Carr, M. H. (1999) *Nature, 397*, 589–591. [7] Carr, M. H. *et al.* (2000) *Icarus, (in press).*

Figure 1. Portion of MOC image AB1-08704 of Nanedi, that shows the best evidence for sustained flow yet found on Mars—the small, inner channel seen at the top of the image.

Figure 2. Portion of MOC image M07-00752, showing a reach in central Nirgal Vallis with "nested" interior channels. In neither case is the volume of eolian sediment sufficient to completely mask the morphology.

Figure 3. Viking Orbiter context for MOC image M02-04864 (inset), showing one of the better branching valley networks within the Warrego Valles, and the outline of Figure 4.

Figure 4. Portion of MOC image M02-04864, showing a portion of one of the Warrego Valles. In this example, it is clear that the valley consists of transecting, elongate, occasionally isolated depressions. Of particular note is the mass movement in the uppermost, center portion of the image.

CONSTRAINTS ON MARTIAN VALLEY FLOW RELATIONSHIPS: M. C. Malin and K. S. Edgett

Figure 1

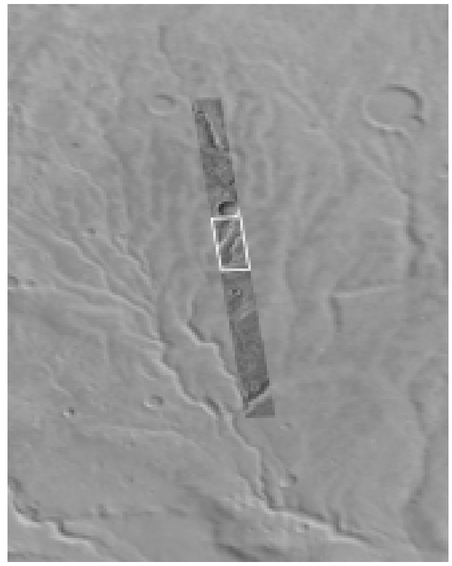

Figure 3

Figure 2

Figure 4