ENIGMATIC VALLEY IN NORTHERN ARABIA: 800 KM LONG, CONSTANT WIDTH, UNDULATING PROFILE, AND NO TRIBUTARIES. A. D. Howard[1] and J. M. Moore[2], [1]Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22904-4123, ah6p@virginia.edu, [2]NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035, jeff.moore@nasa.gov .

Introduction: Most fluvial features on Mars are either dendritic valley networks formed by distributed precipitation or large outflow channels formed by massive floods originating from limited sources. Such fluvial systems usually trend continuously downhill. We discuss the origin of a narrow valley/channel in northwestern Arabia Terra that is unusual in extending more than 800 km from a single source with nearly constant width with an undulating long profile.

Description and Context: The valley originates at the ejecta blanket of a fairly fresh 22.8 km impact crater at 352.7°E, 24.9°N ('A' in Fig. 1) at an elevation of -2275 m, and it terminates at 345.9°E, 33.2°N in the Chryse Planitia ('F') at an elevation of -4070 m, extending 827 km at an average gradient of 0.0022. Valley width varies from about 0.8 to 2.9 km, averaging about 1.52 km, with no downstream trend. Valley depth was estimated from MOLA shot data using the 75th percentile elevation within a 3 km radius of the valley centerline and the lowest elevation in that range to define the channel floor [*1*]. Depths ranged from nearly zero where the valley crosses depressions (e.g. at 'B', '&2', '&4' and 'E' in Figs. 1&2) to about 200 m where it crosses divides (e.g. at '#1', '#3', and '#5' in Figs. 1&2).

The remarkable feature is the valley's undulating long profile (Fig. 3). Major highpoints in the profile are indicated in Figs. 1&2 by '#'-prefixes, and low points by '&'. The upslope-trending valley floor between '&2' and '#3' has 300 m of relief, and that between '&4' and '#5' has 200 m relief. The hump in the profile at 'D' (blue arrow in Fig. 2) is due to ejecta mantling from the 38 km crater to the west.

The valley follows a course across the landscape that would be unlikely if surface flows had followed existing topography. If flow ponded in crater 'B' (Fig. 1), the low divide at the south end of the elliptical crater 'C' would offer a lower drainage to the north than the actual flowpath crossing the divide at '#1', which is 180 m higher. At the divide at '#3" the flowpath crosses the flank of the divide rather than the logical spillway at the col 130 m lower. The flowpath crossing the divide at #5 is slightly higher than one around the NE side of the nearby 23 km crater.

Age of valley. Using the buffered crater counting technique [*2*], the age of the valley is close to the Noachian-Hesperian boundary, within the time frame of formation of most valley networks.

Interpretation: Because of the lack of tributaries and near-constant valley width, all scenarios for valley origin are based upon flow originating from a single local source.

Overland flow integration. By this scenario flow would emerge from 'A', pond in depressions (e.g. 'B', '&2' and '&4') until overflow, gradually extending the channel until it debouched onto the Northern Lowlands. The flow does not follow the most advantageous flowpath, however, crossing higher divides than necessary. Divide breaching by headward sapping might explain the route following the higher divide at '#1' but is unlikely for breaching of the '#3' divide. The positive valley gradients upstream from '#1' and '#3' are also problematic. Drainage of upstream ponding would not lower lake level sufficiently to create the low-lying valley segments unless the cut through the divides were eroded to the level of the depressions. The apparent uphill gradients might be due to deep infilling of the portions of the valleys flowing through the divides through valley wall mass wasting. But if valley integration occurred through overtopping of divides (or possibly through groundwater sapping), drainage through the overflows would likely have been catastrophic, creating wider and deeper valleys downstream from the divides, e.g., as suggested for Ma'adim Valles [*3, 4*]. Valley width is, however, nearly equal upstream and downstream from the divides. Finally, either slow or catastrophic excavation of the valleys by overland flow should result in deltaic deposits within depressions, such as in '&2' and '&4' - these are not apparent. In fact, the valley remains visible through the deepest parts of '&2' and '&4', indicating erosion rather than deposition in depressions.

Overland flow with subsequent tectonic deformation. Most difficulties with the overland flow hypothesis disappear if deformation subsequent to the flow produced the anomalous divides and upstream gradients. However, 200 or more meters of deformation would have had to occur over a few tens of kilometers. No obvious faults, wrinkle ridges, or strong tectonic lineations are present in the vicinity of the anomalous divides.

Overland flow with topographic blockages of lower flow outlets. For example, if the crater at 'C' was filled by a thick deposit, flow might have been forced to cross the divide at '#1'. Such deposits would have had to be friable or sublimatable to be subsequently eroded without significant modification of the channel and without leaving obvious remnants. Although Arabia is a dusty landscape, differential dust deposition seems an *ad hoc* explanation.

Confined flow. The geomorphic evidence favors the involvement of flow beneath an impermeable capping layer. Flow in confined settings occurs from higher to lower hydraulic head (the sum of elevation and pressure heads), but, just as in domestic plumbing, it can involve flows against gravity. A confined flow is consistent with the constant valley width and with erosional excavation both at divides and within basin floors, as in '&2' and '&4'. An obvious confining material that could be subsequently completely removed is ice. Confined channelized flows are common beneath glaciers, resulting in eskers if there is net deposition and tunnel valleys if there is net erosion. Eskers have been postulated to occur on Mars [*5-7*], but tunnel valleys have not been recognized. On Earth tunnel valleys commonly have widths and depths similar to the Arabia valley, but their lengths seldom exceed 100 km [*8-12*]. Most such valleys form beneath temperate glaciers, often with multiple channels and time-transgressive, overlapping sets of channels [*13*]. Tunnel valleys, like eskers, can cross divides and not follow the lowest topographic gradients, e.g. [*12*]. If the Arabia valley is a tunnel valley formed beneath ice, it was sourced from a single water source during a limited time period. The absence of other tunnel valleys, eskers, moraines, or ice-scour features indicates that the mantling ice may have been cold-based. Cold-based glaciation near the highlands-lowlands boundary has been proposed by [*14*].

Source of water. The apparent initiation of the channel at crater 'A' suggests one possible water source being melting of ice due to an impact into the ice sheet, although the crater age relative to the channel is uncertain. Briney artesian spring water emerging beneath the ice is another possibility, given the low elevation. A broad basin occurs on the eastern side of crater 'A' and might have been a source.

Conclusion: The morphology of the valley favors erosion by an ice-confined flow. If ice were present over Arabia during the Noachian-Hesperian transition, it could explain the paucity of valley networks.

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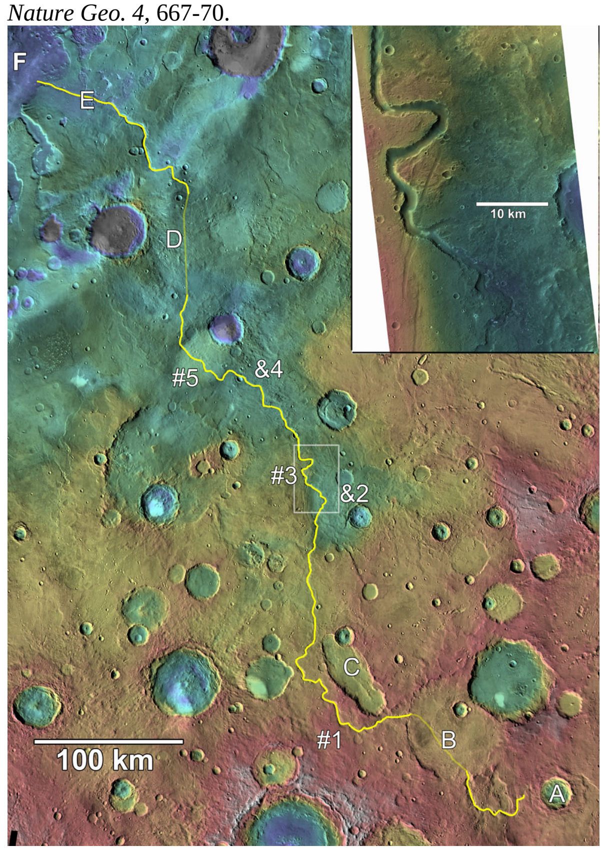

Figure 1. Elevation-cued Themis day IR mosaic showing path of 827 km undulating valley (yellow, greyed where uncertain). Inset is part of CTX image P17_007559_2077.

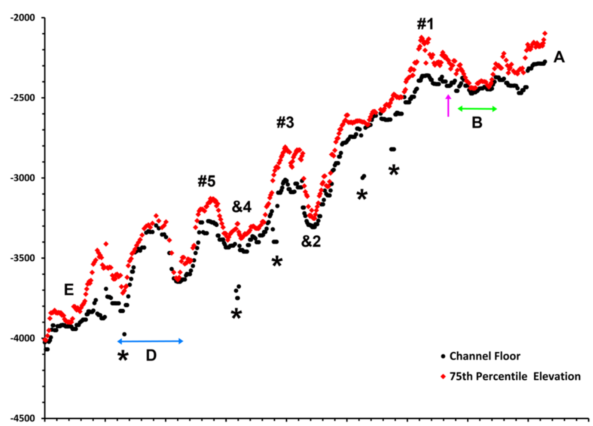

Figure 2. Profile of valley shown in Fig. 1, with locations keyed to Fig. 1. Black dots mark valley thalweg, red dots are level of surrounding terrain. Blue arrow shows ejecta-mantled reach, green arrows the crater floor at 'B', the violet arrow is closest valley approach to crater 'C', and '*'s mark the location of superimposed craters.