TEMPORARY PONDING OF FLOODWATER IN ATHABASCA VALLIS, MARS. D. M. Burr[1], [1]Lunar and Planetary Lab, University of Arizona, 1629 E. University Blvd., Tucson, AZ 85721 (dburr@pirl.lpl.arizona.edu)

Introduction: Athabasca Vallis (Fig. 1) is the youngest known outflow channel on Mars, dated by crater counting at 2-8 Ma [1,2]. In-channel geomorphic features indicative of flooding include streamlined forms, longitudinal lineations, and transverse dunes [1,2]. The streamlined forms have been hypothesized to be primarily depositional, i.e. composed of sediment deposited out of the floodwater behind in-channel obstacles such as impact craters or resistant knobs of bedrock. This hypothesis is based on 1) the difference in morphology between the flatter streamlined form surfaces and the rougher surface of the surrounding terrain, and 2) the strong prevalence of obstacles at the streamlined forms' upslope ends [1,2]. Examination of MOC and MOLA data during hydraulic modeling of Athabasca Vallis showed evidence consonant with this idea of the streamlined forms being depositional. This evidence suggests their formation during a period of slow flowing or temporary ponding of the floodwater in the channel.

Hydraulic modeling of Athabasca Vallis: The upper reach of Athabasca Vallis was modeled using a type of step-backwater model commonly used in terrestrial engineering and paleoflood applications [e.g., 3]. For paleoflood application, the user inputs into the model representative channel cross-sections and a resistance coefficient (Manning's n), and then enters a hypothetical value for the instantaneous discharge. By adjusting this value so that the resultant modeled water height matches the geologic indications of the actual floodwater height, the user arrives at the best estimate for the paleoflood discharge.

Geologic indicators of floodwater height: The geologic indicators in this study had to be identifiable in MOC images for which there are corresponding MOLA tracks, so that individual MOLA data points were available for use in the hydraulic model. Six such indicators were found, two of which are shown in Fig. 2.

Fig. 2a shows the northern edge of the channel; longitudinal lineations created by fluvial flow are located to the south, and higher, uneroded terrain is visible to the north. The paleo-floodwater elevation is interpreted to be at the boundary between the lineated and unlineated terrain, at an elevation of approximately –2528 m.

Fig. 2b shows a streamlined form with a minimum highest elevation of the downstream portion as –2529 m. If this downstream portion is primarily depositional as hypothesized, the floodwater must have been at least as high as the top of the form. Even if the form were erosional, the water must have gotten at least as high as the top of the form to plane it off (although erosion would have been somewhat ineffective in the lee of the impact crater). Thus, the height of the upper surface of the streamlined form, regardless of its mode of formation, is interpreted as representing the minimum peak water height.

Evidence for backwater/ponding: Two pieces of evidence taken together suggest slower flow or temporary ponding of floodwater in the channel:

1) Similarity of paleo-floodwater indicator heights. The two indicators shown in Fig. 2 are at approximately the same elevation. Given the channel slope of .0006 (m/m) and their separation along the length of the channel of ~55 km, these indicators should have been ~30 m different in elevation.

2) Preponderance of streamlined forms upslope of a large in-channel impact crater. A large impact crater is located approximately one-third of the way down the channel (Fig. 1, at the left edge of the black box). The strong preponderance of streamlined forms is associated with this crater. MOLA gridded topography and scattered MOC images show approximately a dozen streamlined forms in the ~100 km length of channel adjacent to or upslope of it, and zero to a few streamlined forms in the ~200 km length of channel down slope of it.

Hypothesis: Slackwater or temporary ponding explains these two features according to the following scenario: The channel curves both north and south around the large impact crater, indicating that the crater modified and therefore predated the flooding. Thus, during at least initial flow, ejecta from that impact crater would have been present to block the floodwaters, creating a slackwater or temporarily ponded zone upslope. Water flow on Mars should carry more sediment than on Earth [4], and the heavy sediment load carried by the floodwater would have been deposited in this zone during the slower/stagnant flow. As the ejecta damming the floodwater was gradually eroded away, the most of the sediment would likewise have been washed away with the ponded water's outflow. However, sediment behind obstacles would have been protected from entrainment, and would have been streamlined during this outflow.

Alternative hypothesis--post-flood magmatic subsidence: The Cerberus Fossae have been a source not only for water but for lava as well [e.g., 1 and references therein]. Post-flood extrusion of lava could have resulted in subsidence of the surface over the Cerberus Fossa at the origination point of the channel.

This collapse would have lowered the channel slope below what it was during flood flow, reducing the elevation of the uppermost region of the channel more than the lower reaches, and producing the observed similarity in elevation of the paleo-flow indicators. However, significant collapse features are not apparent in MOC or MOLA data; and the strong preponderance of streamlined forms immediately upstream of the impact crater remains accounted for. This hypothesis is therefore discounted in favor of the temporary ponding hypothesis.

Source of the sediment: The sediment deposited in the streamlined forms was in transport by the floodwater. The floodwaters would have been carrying material entrained from the Martian surface during the carving of Athabasca Vallis. Because they emanated from the Cerberus Fossae, the floodwaters may also have been carrying sediment from within the Fossae. Since the Fossae were a source for both water and lava, this sediment may have been hydrothermally altered. Athabasca Vallis was a candidate landing site for the Mars Exploration Rovers. If future landed missions target Athabasca Vallis, they may be able to collect sediment samples from the streamlined forms of such subsurface material.

Modeling results: The hydraulic modeling indicates a flow of 1 – 2 million m^3/s could have flowed down Athabasca Vallis. There is circumstantial evidence for more than one flood flow [2], however, which would introduce error into this estimate. This result is in agreement with earlier published estimates [1].

References: [1] Burr D.M. et al. (2002) *GRL 29* (1), 10.1029/2001GL013345. [2] Burr D.M et al. (2002) *Icarus 159* (1) 53-73. [3] O'Connor J. E. (1993) *GSA Spec. Paper 274.* [4] Komar P.D. (1980) *Icarus 42*, 317-329.

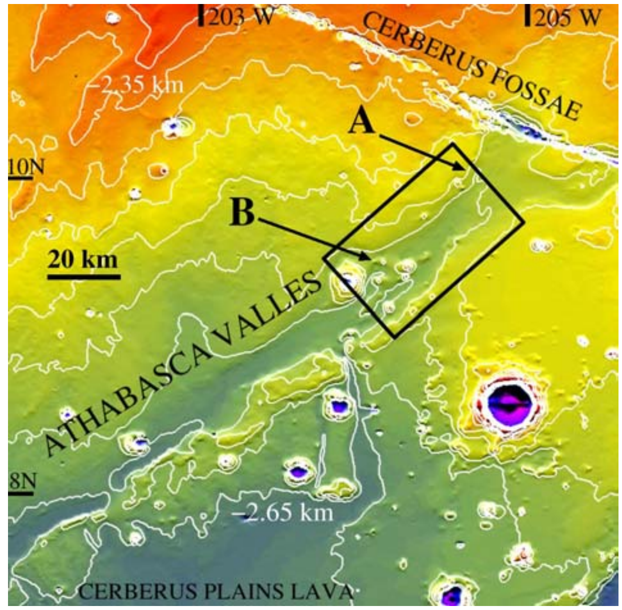

Figure 1: MOLA gridded topography over Athabasca Vallis. A and B refer to locations of Figure 2, A and B. At the southwestern edge of the black box is seen the large impact crater whose ejecta is hypothesized to have created a backwater.

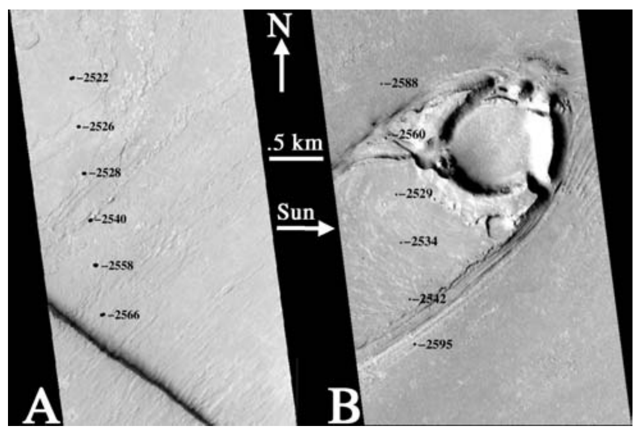

Figure 2: Portions of MOC images M02-01973 (A) and M07-00614 (B), showing paleo-floodwater height indicators. MOLA elevations in meters are overlain in black (the dashes preceding the numbers are negative signs).