Modeling Catastrophic Discharges in Osuga Valles, Mars

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1. Introduction: Osuga Valles (OV) is one of many catastrophic outflow channels found on the surface of Mars. It is centered at about 14°50'S and 37°25'W just southeast of Valles Marineris and spans approximately 160 km in length. OV provides evidence for paleo flood events that appear to emerge from a chaotic terrain and terminate into depressions or cavi. There have been several hypotheses [1,2,6] for how groundwater might be catastrophically released from the subsurface, but none can really explain the enormous volumes required to form the outflow channels, especially through porous media. However, we have been investigating some potential mechanisms.

Osuga Valles contains enormous channel bedforms such as streamlined islands and grooves, and forms both singular and anastomosing channel segments. We can infer floods occurred periodically - if not seasonally - from the cross-cutting channels in the anastomosing region. Additionally, in Figure 1 below, there are two sources in the chaotic terrains (lower left) where the lower southern appears to be the most recent collapse and source of outflow. Because of this unique geomorphology, we are interested in the history of flooding in this system and the properties of the subsurface which produced these high magnitude flows.

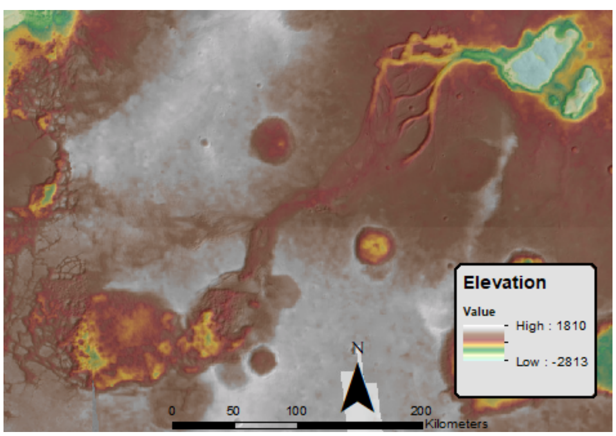


Fig 1. Surface topography of the Osuga Valles channel. The chaotic terrains are in the southwest and the channel terminates into large depressions.

2. Discharge Modeling: We use the Hydraulic Engineering Center's River Analysis System (HEC-RAS)[4] to generate over 20 2D models of catastrophic flood events. We then re-ran the simulations under two additional Manning's n values. The additional n values are the roughness coefficients representing the lower and upper bounds for boulder lined channels[3].

Using multiple Manning's n enables us to develop rating curves. These curves provide an estimate for the approximate discharge (Q) for a given depth at a given location in the channel. In Figure 2, we have 4 cross-sections (black lines: P1-P4) which measure the stage for each inflow rate, then plot a discharge (Q) vs stage height as a scatter plot to develop the rating curve. We have modeled just the southern region of collapse (Figure 2). The northern source region will also be simulated. We assume these flows from the northern source are early flooding, if not the initial flows for OV.

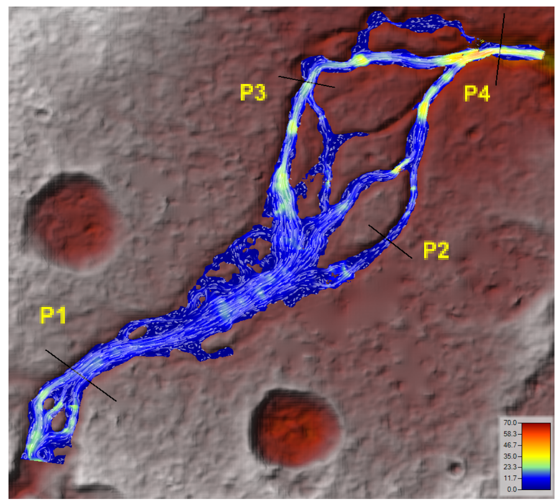
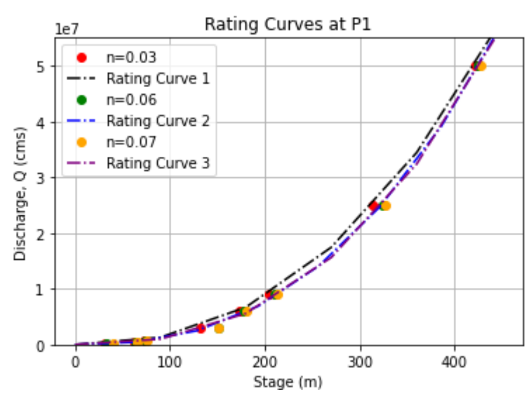


Fig 2. Model simulation using HEC-RAS for $Q = 9 \times 10^6$ cms. Flow is northeast and is shown here with Velocity vectors in m/s.



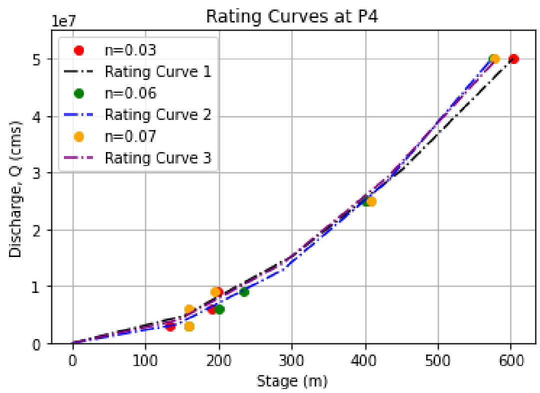


Fig 3a,b: Rating Curves developed from HEC-RAS results for all three Manning's n values. Only two of four profiles are shown here. **(3b)** Smaller flows do not reach the furthest cross-section and are all well below 1 x 10^7 cms. Larger flows with less data points result in larger uncertainty.

Table 1. Stage height (Stage) associated with Discharge (Q) at each cross section (P) assuming a given Manning's n

		n = 0.03	**n = 0.06**	**n = 0.07**
	Q (m^3/s)	**Stage (m)**	**Stage (m)**	**Stage (m)**
P1	1E05	205.0	206.3	214.0
	4E05	236.6	238.0	238.6
	6E05	246.0	248.5	249.4
	3E06	305.5	325.3	325.3
	6E06	346.8	351.5	354.6
	9E06	378.4	383.7	386.8
	2.5E07	487.1	498.4	500.8
	5E07	595.9	599.3	601.1
P2	3E06	27.9	68.5	68.5
	6E06	87.1	91.8	93.6
	9E06	121.7	128.7	131.4
	2.5E07	265.8	269.9	271.9
	5E07	368.7	372.8	363.9
P3	3E06	-173.1	-148.0	-148.0
	6E06	-98.1	-106.5	-96.7
	9E06	-60.8	-68.1	-69.2
	2.5E07	35.8	39.8	41.6
	5E07	149.0	151.5	151.5
P4	3E06	-948.0	-923.9	-923.6
	6E06	-891.8	-881.9	-923.3
	9E06	-883.8	-848.5	-886.7
	2.5E07	-679.6	-680.7	-673.1
	5E07	-478.6	-506.7	-504.5

3. Volume Displacement: To determine the quantity of both water and sediments displaced by the subsurface outflow, we need to estimate the total volume displaced from the source regions and throughout the channel. We use ESRI's ArcMap to resurface OV and estimate the total volume removed. We assume the elevations surrounding OV are the original elevations prior to flooding and collapse, and are height references for 'filling' in the channel. This will be used as the DTM for the early flood modeling from the northern chaotic terrain. Current estimates for total volume are on the order of 2 to 4 x 10^{12} km^3.

4. Relative Ages and Geology: Additional work on the crater dating[8] and the geological composition[7] of the area is also being analyzed. With the crater counting, we can identify the relative ages at which flooding occurred and estimate over what time periods. The geology also helps constrain the range on the Manning's roughness coefficient.

5. Acknowledgments: This work was carried out under the guidance of Dr. Virginia Gulick and Dr. Tao Liu. Data obtained from ESA for HRSC DTMs and HiRISE for Osuga Valles DTMs.

5. References:

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