ESTIMATED MINIMUM LIFESPAN OF THE JEZERO CRATER DELTA, MARS

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Introduction: Deltas on Mars provide an important record of surface water flow. Understanding the formative timescale of deltas is fundamental to understanding the history of water on Mars. Different type of deltas have been found on the red planet [1]: from simple stepped deltas [2,3,4,5] to more complex and lobate [6,7,8] as well as Gilbert type [9]. However, many analyses until now have a number of debatable assumptions about main processes, as well as inconsistencies in application of quantitative methods to calculate activity and duration. Jezero crater has been selected as the NASA 2020 rover landing site and we would better understand his timing and duration.

Methodology: We use the model of [10] to estimate the duration of the Jezero fluvial system and we further test it on well constrained terrestrial cases to assess general validity. We run a number of conditions for the most uncertain and sensitive variables such as grain size and channel width. The channel width, depth and slope can be derived from visible images and digital elevation model. Channel width, depth and slope were carefully measured trough HiRISE DEM for the Jezero delta. The model [10] is based on steady and uniform flow equal to the water surface slope and channel bed surface slope. We assume 5 meters water depth. The delta surface, surface slope and volume, the eroded sediment valley volume, the rim diameter, the observed depth below the rim peak and the top shoreline (that in this case match with the elevation of the delta top) can be accurately delineated through the HiRISE DEMs. We assume transport of one sediment size whereas in reality there may be a mixture. We modeled several scenarios assuming one grain size per each simulation. It is not possible to determine washload from the capacity predictors because that it is supply-limited, not capacity-limited.

Lake Infilling and Delta Formation: Two fluvial valleys enter into Jezero crater, to its west and north. We model the contribution of the main valley at the origin of the western depositional fan. The northern valley does not show evidence of delta deposits and is poorly developed as well. We split the Jezero delta evolution history in two different phases: phase 1 concerns the basin infilling just after the breaching of Jezero rim and before the delta formation; phase 2 concerns the development of the delta. Further, we also discuss the timing of delta formation considering a delta paleovolume of 15 km^3. Each simulation is initialized by choosing the channel slope, width, and length scale, as well as the crater diameter, grain size.

The results of the simulations using relevant Jezero inlet channel morphological and sedimentological parameters are shown in Figures 1,2.

Evaporation: Concerning the water balance we can calculate discharge, which fills basin, but we cannot measure the evaporation or pan-evaporation rate due to the lack of constraints on paleoclimate parameters, although this is a key parameter for the lake lifetime estimate. One of the main uncertainty of the pan-evaporation method, already used in Eberswalde, is due to pan coefficient itself [11], which is between 0 and 1, 0 in the case of warm climate and low humidity and 1 for cold climate and high humidity and the evaporation from a pan can be used as a good indicator of the evaporation from the surrounding environment only when land-surface moisture is in ample supply [12,13]. Complex equations, such as for example Penman-Monteith equation, commonly used to estimate evaporation on Earth open lake require the knowledge of several paleo-environmental parameters, which are impossible to be determined on Mars.

Breaching and Lake Outflow: The east side of the Jezero rim is breached at -2410m. Dam breaching could have occurred due to rim failures by overtopping and erosion by the overflowing water. Starting from -2250m we identified three main breach episodes that released a total water volume of about 240 km^3. Due to the strong erosion that affected the Jezero crater rim, it is not possible to investigate the morphology above -2250m.

Intermittency: This parameter cannot be considered in the basin analysis because there is no way to define all the geological and geomorphological elements necessary for its correct estimation. Furthermore, the Jezero delta has not been further carved by channel until the basin floor, which we would expect if the lake had cyclically dried and wet periods.

Modeling parameters: The Jezero hydrological modeling done in this work has revealed a complex evolutionary basin's history. Nevertheless to constrain the minum duration of the Jezero lake we made some assumptions and it was not possible to consider the whole 56 km^3 eroded (from the whole watershed, not from the observed fan). The estimations were made only for the late-stage, fan formation of ~5 km3 and putative 15km^3. The Kleinhans model uses types different parameters: fixed, derived and variable. Fixed parameters chosen using DEMs are: channel width, depth, slope, fan surface, fan volume, eroded sediment valley volume, rim diameter. Derived parameters are: discharge rates estimation (1,800-2,600 m3/s), etc.; water/sediment ratio suspension dominated (~2000-3000), etc. Variable parameters: various grain size (D50) (fine sand to cobbles).

Preliminary results: The lake filling (phase 1) took few years depending on the channel width and grainsize is not relevant to estimate how much time needed for water basin infilling. The fan formation (phase 2) by continuous flow took hundreds of years varying grain size from gravel to cobble and channel width as well. As best guess we considered grainsize ranging between 8 and 14 mm, according with grainsize measured on Mars by rover missions in similar environments. Grainsize (D50) is very relevant to estimate how much time needed for fan formation (factor of 30) more than channel width (factor of 3). This duration corresponds to the minimum duration of the late stage episode, the lifespan of Jezero paleolake may have been longer but geological evidence may be harder to find. Grain size represents a key parameter because the bed load function of [14] and the suspended load functions decrease with grain size due to the settling velocity increase as well as the transport rate. Several authors based their hydrological estimations simply assuming a sediment concentration instead of sediment load. Hydrological timing estimate based on sediments concentration, which is function of the shear stress, could lead to an incorrect estimate of the duration of the fluvial timing.

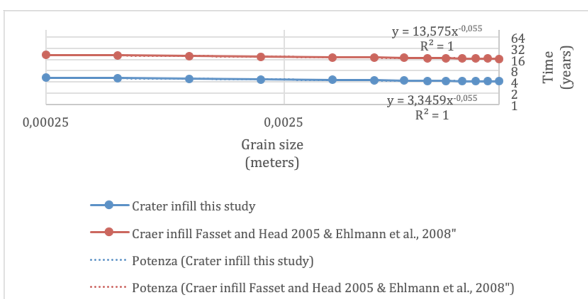

Figure 1 Basin infilling assuming continuos flow (no sesonal flow, no evaporation, no percolation). For the red line was used a more conservative approach considering the channel width used also in Fasset 2005 and Ehlmann 2008: 50 meters.

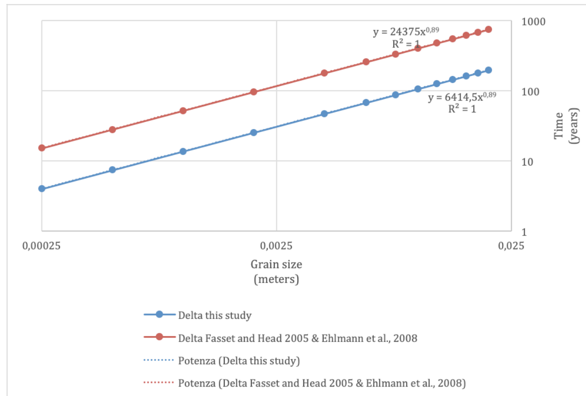

Figure 2 Delta formation assuming continuos flow (no sesonal flow, no evaporation, no percolation). For the red line was used a more conservative approach considering the channel width used also in Fasset 2005 and Ehlmann 2008: 50 meters.

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