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Hydraulic analysis of a Martian paleolake

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One of the most interesting morphological feature on the surface of Mars are paleolakes: time capsules and low-energy depositional settings that preserve hints on the ancient environment and, possibly, traces of life. On Earth, lakes host a huge diversity of habitats where life is flourishing; hence, on Mars, they may have once supported life too. In order to understand the paleohydrology of these basins, the estimation of the water discharge flowing into their tributary and/or outlets can give important clues on the water cycle on the planet. On Mars, the most common modeling used to reconstruct the hydraulic properties are based on the adaptation of terrestrial empirical relationship, less focusing on more sophisticated hydraulic models.

The main objective of this study is to separately analyze the hydraulic characteristics of the tributary and the outlet of a paleolake located in the Menmonia quadrangle by using an hydraulic model based on the energy and momentum equations of the body of water enclosed in the channels. The lengths of the analyzed river reaches are $\sim$ 10 km and $\sim$ 19 km, the outlet and the tributary respectively. A Monte Carlo procedure coupled to geomorphological evidences of the paleowater surface (e.g. terraces levels) were used to constrain the hydraulic parameters of the system. The Mars Express High-resolution stereo camera digital elevation model, H31850000DA4 with a spatial resolution on 75 m, is hence used to characterize the geometry of the study area.

In this contribution we provide estimates on the magnitude of the bankfull discharge and roughness coefficient of the tributary and the outlet of the paleolake; moreover, on the basis of these results, the probable water depth of the lake is inferred. Finally, a discussion on the possibility that the system inlet-lake-outlet was acting simultaneously is also presented. Consequently, a sensitivity analysis is performed to examine the accuracy of the results to the main sources of uncertainty concerning the methodology, as well as, the uncertainty in the geomorphological evidences used to constrain the hydraulic modelling.

Given the comparable discharge estimates of the tributary and the outlet, as well as the coherent elevation and width of their mouths into the lake, the results suggest that both channels were most probably acting simultaneously during their last evolutionary phase, with a discharge equal to $\sim$ 6000 $m^3 s^{-1}$ and a water surface elevation in the lake equal to $\sim$ -1400 m. This contribution supports the hypothesis of an ancient and articulated hydrologic system acting in the study area.