

A multidisciplinary approach to the study of the Chaotic Terrains on Mars

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Chaotic terrains on Mars display common characteristics, such as irregular arrays of fractured and tilted blocks up to tens of kilometers in size and their occurrence in depressions of hundreds of meters deep. Moreover, they represent the source of the majority of the Hesperian outflow channels. These features spark the question which subsurface mechanism is responsible for the formation of chaotic terrains and release of major quantities of water in few. Morphological and hydrological observations fit well with a scenario of catastrophic water release from a buried sub-ice lake. In this scenario, the Chaotic Terrains would result from the collapse of sediments and ice covering the lake. The sub-ice lake would arise from slow melting of, and sedimentation on, a crater ice sheet. In order to investigate whether this scenario is feasible from a physical perspective, we perform a multidisciplinary study of the Chaotic Terrains. In particular, we perform a statistical analysis of their morphometric characteristics, and we investigate whether their surface morphology may be a consequence of the collapse of the infill of a crater.

Based on their morphometric characteristics, we find that these landforms have a common origin. In particular, the investigated landforms show diameter-depth correlations similar to those that impact craters of equivalent diameters exhibit. We also find that the observed amount of collapse of the collected features is strongly correlated to their diameter. Furthermore, the linear relation between the minimum filling and pristine depth of craters, the constant ratio between collapse and the amount of filling and the fractured and chaotic aspect of the filling agree with melting and subsequent collapse of an ice layer below a sediment layer.

We investigate whether this surface morphology may be a consequence of the collapse of the infill of a crater. We perform numerical simulations to evaluate the distribution of fractures within the crater and the influence of the crater size, infill thickness, and collapsing depth on the final morphology. The comparison between model predictions and the morphology of the Martian Chaotic Terrains shows strong statistical similarities in terms of both number of fractures and correlation between fractures and crater diameters. No or very weak correlation is observed between fractures and the infill thickness or collapsing depth. The strong correspondence between model results and observations suggests that the collapse of an infill layer within a crater is a viable mechanism for the peculiar morphology of the Martian Chaotic Terrains.