Geomorphological evidence of localized stagnant ice deposits in Terra Cimmeria, Mars

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Abstract

The presence of snow and ice at mid-latitudes of Mars cannot be explained by current climatic conditions, as surface ice is unstable. However, a large variety of debris-covered glaciers have been observed at both mid-latitudes. Here, we report the presence of local, small-scale, and debris-covered stagnant ice deposits on the floor of a valley system in Terra Cimmeria. The VFD were observed within the limits of the ejecta blanket of the Tarq impact crater, the ejecta streaks of which are partly covering the areas surrounding the VFD as well as the surface of a few VFD. The central pit of this impact crater points to a potential impact into an ice-bearing substrate. The presence of glacio-fluvial valleys further supports this notion. Our geomorphological observations indicate that the VFD are small-scale debris-covered stagnant ice deposits, and are currently in degradational stage. These observations include: 1) the convex-upward morphology, 2) the infilling, in some cases, of the entire valley depth, 3) crevasses on their surface, and in some cases traces of volume loss of the deposit, and 4) sublimation pits. The local distribution of the VFD and their stratigraphic relation to the ejecta blanket, combined with the evidence of the Tarq impact crater having been formed in an ice-bearing substrate, suggest that the distribution and thus formation of VFD may be linked with the Tarq impact event. Our crater-size frequency distribution results, however, show two major resurfacing events in the area, and therefore two possible formation times for the Tarq crater: Late Hesperian or Middle Amazonian. Thus, we suggest two formation scenarios for VFD: I) distribution of ice due to impact into shallow ice during the Middle Amazonian. II) Post-impact deposition of VFD due to precipitation. In both scenarios, ice preservation is most likely due to a lag of dust and debris deposited in the valley's topographic lows. Scenario I is more consistent with our geomorphological observation of the VFD being overlain by ejecta streaks. Our results highlight the importance of local geological events and conditions in the distribution and preservation of buried ice deposits on Mars, and suggest that more small-scale and debris-covered ice deposits may exist in the mid-latitudes than previously thought. The buried ice deposits are important for better comprehending the climate during their emplacement, for preservation processes, for the identification of special regions for future human exploration and/or in situ resource utilization (ISRU), and for search for traces of past life on Mars.

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