EPSC Abstracts
Vol. 11, EPSC2017-576, 2017
European Planetary Science Congress 2017


# Ice-bearing deposits in the southern mid-latitude regions of Terra Cimmeria, Mars

**S. Adeli** (1), E. Hauber (1), R. Jaumann (1,2), G. Michael (2), and P. Fawdon (3)
(1) Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), Institute fuer Planetenforschung, Rutherfordstr. 2, 12489 Berlin, Germany (Solmaz.Adeli@dlr.de) (2) Freie Universität Berlin, Institute of Geological Sciences, Malteserstr. 74-100, 12249 Berlin, Germany. (3) The Open University, Walton Hall, Milton Keynes MK7 6AA.

## Abstract

In mid-latitude regions of Mars there is clear evidence of ground ice deposits whose formation has been assumed to be a result of Amazonian-aged climate changes, triggered by obliquity variations. We report here the presence of a new class of locally-observed deposits observed on the floor of an Amazonian-aged valley. These valley fill deposits (VFD) show evidence of shallow ice and are characterized by their convex-upward surface topography, crevasses, ablation moraines, sublimation pits, and ring-mold craters.

## 1. Introduction

Global circulation models (GCM) suggest that obliquity oscillations caused the mobilization of ice from polar regions and its re-deposition at lower latitudes [1, 2]. They show that during high obliquity periods, ice can be deposited almost anywhere in the mid-latitudes and during low obliquity ice is transported back to the poles [2-4]. Although the obliquity variations are not predictable for periods more than 20 Ma ago [5], it is likely that the surface of Mars, during Amazonian, has been repeatedly undergone such climate changes leading to deposition and sublimation/evaporation of ice-rich material [e.g., 3, 5, 6]. This study describes, for the first time, well-preserved glacial-like deposits in Terra Cimmeria, which are defined here as valley fill deposits (VFD) (Fig. 1-a). They are located on the floor of a valley system which bears a record of Amazonian-aged fluvial and glacial processes [7].

## 2. Morphological characteristics

Several deposits on the flat floors of S-N trending valleys south of Ariadnes Colles (34°S, 172°E) are characterized by (1) widths and lengths of a few kilometers, (2) convex-upward surface topography, and (3) pits and crevasses on their surfaces. These valley fill deposit (VFD) are located a few tens of kilometres east of the Tarq impact crater. Several of the VFDs are situated within the visible ejecta blanket of the Tarq Crater (Fig.1-a). The crater ejecta are clearly observable on the surface and surrounding area of those VFDs. Our crater size-frequency distribution results from the Tarq crater ejecta shows a model age ~µ410 (±60) Ma for the impact crater, which corresponds to middle Amazonian (epoch boundaries from [8]).

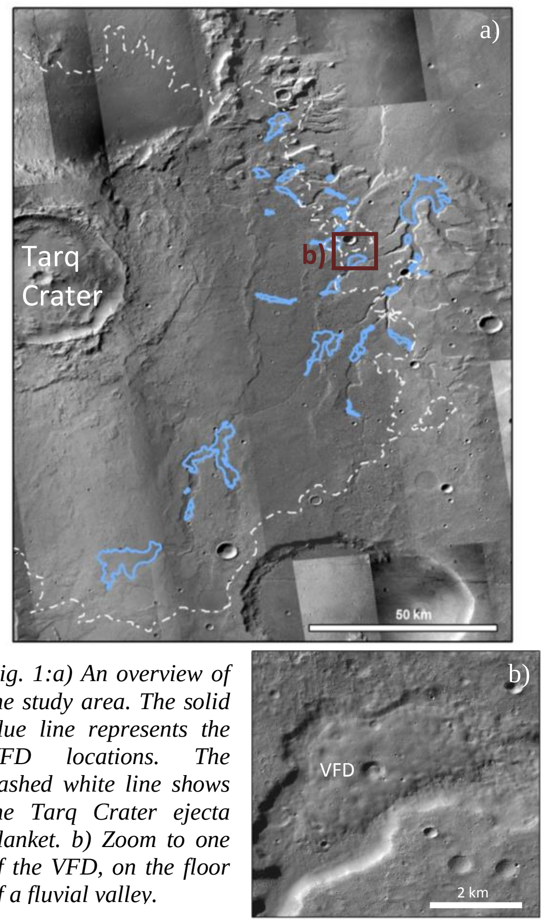


*Fig. 1:a) An overview of the study area. The solid blue line represents the VFD locations. The dashed white line shows the Tarq Crater ejecta blanket. b) Zoom to one of the VFD, on the floor of a fluvial valley.*

The VFDs have individual surface areas of a few km$^2$ to a few tens of km$^2$ (Fig1-b). In some cases they are located in the centre of the valley floor, whereas in other cases they cover the entire width of the host valley, indicating their post-valley formation. The valley width could reach up to a few kilometres, in some areas. Using a HiRISE DEM, we observed that the VFD in the thickest part has a thickness of ~30 meters. The latitude dependent mantle (LDM) is also partly covering the VFD, and the surface of the VFD is outcropped where the LDM has been degraded or sublimated.

The surface of VFD shows only few impact craters, with diameters equal or smaller than ~700 m. Craters larger than 70 m are mostly degraded, their rims show almost no positive relief (at CTX resolution) and they have flat floors. Smaller modified craters have been observed, but there are also a few small fresh impact craters (smaller than 70 m in diameter) which do not show any modification of their rims and walls. On the surface of several VFD, we observed craters with a few hundred meters in diameter, bowl-shaped, and rimless, which have a flat floor. They have very similar characteristics to impact craters on LDA and LVF surfaces in mid-latitudes, which are termed ring-mold craters (RMC) by [9] and are thought to be a result of impacts into shallow buried ice.

Where higher resolution data are available, we can observe linear features, cracks, and crevasses on surface of VFD. Fig. 1-b shows one VFD which partly covers its host valley and display several crevasses at the surface as lateral or transverse crevasses. Transverse crevasses may indicate tensile stress caused by viscous flow of the deposit. In several cases, in front of the VFD margins, there is a zone up to 3 km of length, where the valley floors are rougher than further down the valley. We infer that this rough zone corresponds to sediment accumulation similar to moraine-like material in front of a glacier that moves down the valley. At the contact between the VFD and the valley walls, we observe several sublimation pits a few tens of meters wide and aligned along a preferential direction on the border of the VFD.

# 3. Discussion

The VFD have been observed on the floor of a valley system with traces of early to middle Amazonian fluvial activities [7] and our observations point to a post-valley formation for the VFD. The VFD is characterised by a convex-upward shape, transverse crevasses, sublimation pits, and association with moraine-like deposits. These characteristics, together with evidence of ring-mold craters, suggest that VFDs are ice-rich deposits with a thickness of a few tens of meters. The VFD has been later partly covered by LDM, which shows evidence of degradation, such as retreating boarders, sublimation pits, and scalloped surface.

The VFDs are partly distributed within the area covered by the Tarq Crater ejecta blanket. The superposition of the ejecta blanket on the VFD, points to the pre-ejecta distribution formation of these ice-bearing deposits, however, it is unclear whether the VFD formed prior to the impact event, or its deposition was contemporary with the impact and distribution of the ejecta blanket. In the former case, the ejecta blanket may have preserved the VFD by covering it. This ejecta cover had later been partly degraded, which led to the exposure of the currently present VFD in the area. On the other hand, in the latter case, the impact event may have occurred in ice-rich strata, which, subsequently, may have distributed a mixture of ejected material and ice, in other words, icy ejecta.

# 4. Implication:

The accumulation of ice/snow at mid-latitude regions cannot be explained by the current climatic condition of Mars, as the atmosphere does not sustain snow/ice accumulation and surface ice is unstable at mid-latitudes [10]. Therefore, the glaciation and deposition of VFD, regardless of the formation mechanism, should have taken place under different climatic conditions in the past. We conclude that the presence of ice-rich VFD underneath the young LDM is an evidence of an episodic and multi-event process of ice emplacement in the mid-latitude regions of Mars during the Amazonian period.

# 5. References


[1] Forget, F., et al. (2006), *Science*. *311*, p. 368-371.
[2] Madeleine, J.-B., et al. (2009), *Icarus*. *203*, p. 390-405.
[3] Smith, I.B., et al. (2016), *Science*. *352*(*6289*), p. 1075-1078.
[4] Levrard, B., et al. (2007), *Journal of Geophysical Research: Planets*. *112*(*E6*), p. E06012.
[5] Laskar, J., et al. (2004), *Icarus*. *170*, p. 343-364.
[6] Head, J.W., et al. (2005), *Nature*. *434*, p. 346-351.
[7] Adeli, S., et al. (2016), *Icarus*. *277*, p. 286-299.
[8] Michael, G.G. (2013), *Icarus*. *226*(*1*), p. 885-890.
[9] Kress, A.M. and J.W. Head. (2008), *Geophysical Research Letters*. *35*.
[10] Mellon, M.T. and B.M. Jakosky. (1995), *Journal of Geophysical Research*. *100*, p. 11781-11799.