EPSC Abstracts
Vol. 6, EPSC-DPS2011-255, 2011
EPSC-DPS Joint Meeting 2011
© Author(s) 2011

Extensive glaciation of Valles Marineris (Mars) revealed by sackung, trimlines and ablation tills

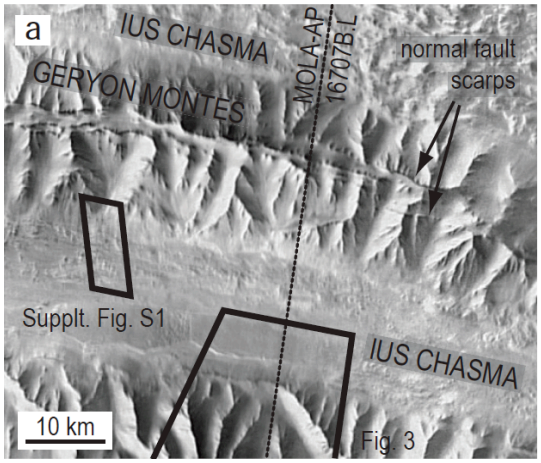
O. Bourgeois (1), D. Mège (1), M. Gourronc (1), B. Bultel (1), M. Massé (2) and L. Le Deit (3)
(1) LPGNantes, CNRS, Université de Nantes, Nantes, France (olivier.bourgeois@univ-nantes.fr). (2) LPL, University of Arizona, Tucson, USA (marionmasse@email.arizona.edu). (3) DLR, Berlin, Germany (Laetitia.Ledeit@dlr.de)

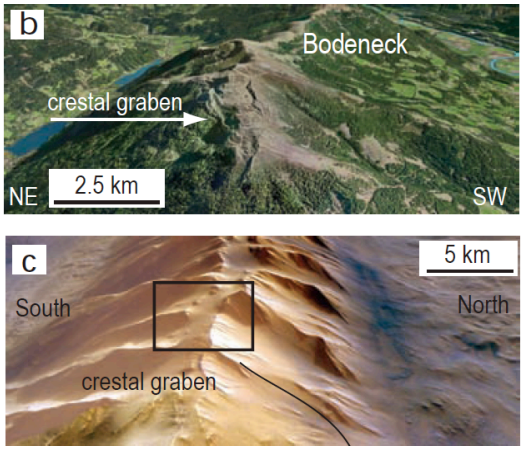
Introduction

Observational evidence for past glaciations at tropical to mid-latitudes of Mars has been abundantly reported in the literature during the last 10 years. Martian global climate models successfully account for these glaciations. Interestingly, some climate models also predict significant accumulations of ice in the equatorial Valles Marineris during past periods of high obliquity. Observational evidence for such extensive glaciations is still lacking however. We provide such evidence here.

1. Paraglacial collapse of Valles Marineris basement ridges

Valles Marineris is a series of 4-10 km-deep interconnected troughs that covers a surface area of 650 by 2000 km in the equatorial region of Mars. This is basically a system of alternating grabens and horsts striking E-W. The horst topographic ridges display two remarkable deformation features: crestal grabens, indicating ridge-top splitting, and uphill-facing normal faults scarps on ridge flanks (Figs. 1a,c,d).





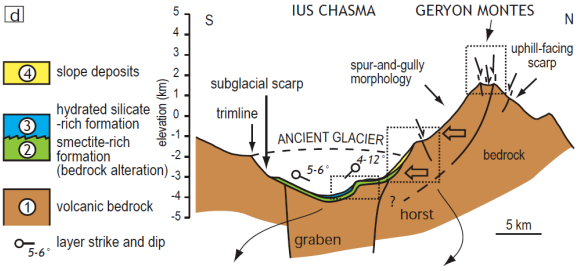


Figure 1: a) Ridge-top splitting of Geryon Montes in Valles Marineris. b) Ridge-top splitting of a crest separating two formerly glaciated valleys in the Austrian Alps. c) Focus on the crestal graben at the top of Geryon Montes. d) Model of development of ridge-top splitting and up-hill facing fault scarps by ridge debutressing during deglaciation of Ius Chasma.

These two features are diagnostic of sackung, a large-scale and slow gravitational mass wasting mechanism of topographic ridges. On Earth, sackung has been observed almost exclusively in mountain ranges that were glaciated during the Quaternary (Fig. 1b). Studies of these terrestrial examples have demonstrated that slope debuttressing by the removal of valley glaciers on both sides of topographic ridges

is a key process for sackung to initiate, and may be in some cases assisted by postglacial unloading and rebound. From the excellent correlation between sackung occurrences and paraglacial settings on Earth, we infer that sackung in Valles Marineris is likely to result from deglaciation of the ridge surrounding chasmata (Fig. 1d).

2. Trimlines and ablation tills

This interpretation is supported by a series of morphological similarities between chasmata in Valles Marineris and formerly glaciated valleys on Earth. First, both kinds of valleys have slopes where the bedrock displays spur-and-gully morphologies and flat floors where the bedrock is covered with soft sediments (Fig. 2).

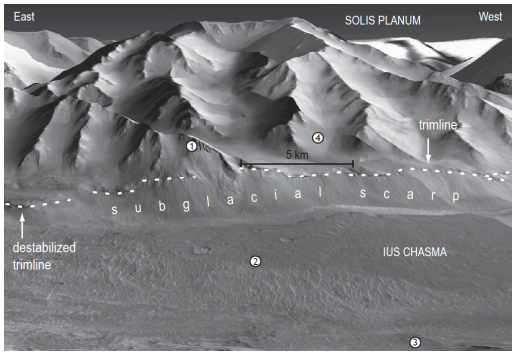


Figure 2: Example of a trimline separating subglacial erosional scarp (bottom) from periglacial spur-and-gully morphology (top) along Ius Chasma wallslopes.

Spur-and-gully morphology on slopes of terrestrial glacial valleys is due to periglacial weathering processes acting above the surface of glaciers, whereas flat valley floors generally correspond to glacial and/or post-glacial sedimentary fills. In areas of Valles Marineris where the spur-and-gully morphology has not been removed by further erosional processes, the base of the slope usually displays a continuous scarp (Fig. 2). The best interpretation for this continuous basal scarps is subglacial erosion of the bedrock by valley glaciers that formerly covered the chasma floors. The trimline marking the boundary between the subglacially eroded basal scarp and the overhanging periglacial spur-and-gully morphology can be identified in many parts of Valles Marineris but it has frequently been eroded or covered by debris accumulations. Trimline height above chasma floor can be used to infer the maximal thickness of the former glacial infill; measured values in Ius and Candor chasmata are in the range of a few hundred meters to more than 1 km.

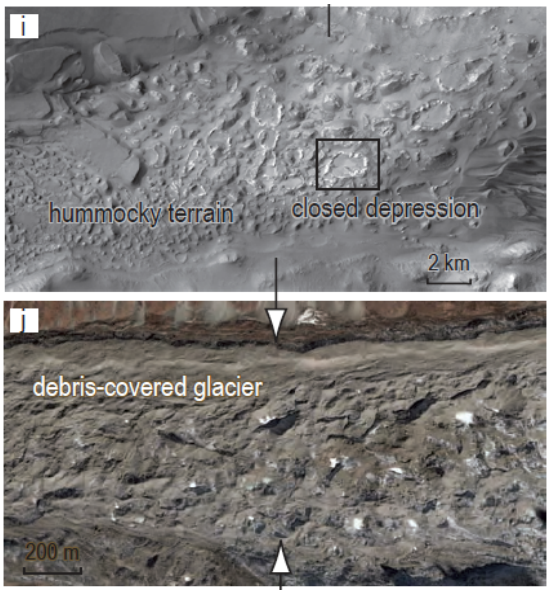


Figure 3: Comparison between hummocky terrain covering the floor of Candor Chasma (top) and ablation till covering a terrestrial glacier (bottom).

Many chasma floor landforms can also be interpreted as having a glacial origin. Hummocky terrains similar to terrestrial ablation tills left after retreat of valley glaciers are observed at the base of ridges affected by sackung (Fig. 3). They are sometimes associated with stripes of dark detrital accumulations, interpreted in other areas of Mars as possible volcanic-derived tills and accumulating in Valles Marineris as moraines of various types, including streamlined moraines and ablation and frontal moraines.

3. Conclusions

Gravitational collapse of basement ridges, trimlines, subglacial erosional scarps and ablation tills provide evidence that Valles Marineris chasmata were once extensively filled by valley glaciers. These glaciers were as thick as 1 km. Stratigraphic relationships indicate that these equatorial glaciations are older than 1.4 Gy and younger than 3.5 Gy, which provides new and strong constraints for Martian climate models.