

THERMOKARSTIC DEGRADATION OF LOBATE DEBRIS APRONS AND FRETTED CHANNELS. N. Mangold, F. Costard and J.-P. Peulvast, Orsay-Terre, Equipe Planétologie, UMR 8616, CNRS et Université Paris-Sud, Bat. 509, 91405 ORSAY Cedex, France, mangold@geol.u-psud.fr.

Introduction: Lobate debris aprons are landforms observed in the mid-latitudes regions of Mars at the foot of kilometer high scarps [1]. Because of their lobate front and convex shape they have been interpreted as the result of the viscous deformation of an ice-rock mixture [2]. Recent analyses of MOLA data confirm these previous conclusions [3]. Fretted channels correspond to lineated valley fills interpreted in the same way by viscous deformation of ground ice but guided by the shape of the valley [2]. New MOC high resolution images of the surface of both lobate debris aprons and fretted channels show mysterious network of knobs and highly dissected units. This study proposes to explain these landforms by a thermokarstic degradation due to the sublimation of ground ice.

Observations: A close look to the surface of lobate debris aprons show complex landforms at the scale of several hundred meters (Fig. 1 and 2). Three morphologic units can be distinguished: (1) Flat unit with several pits and troughs; (2) Partially dissected unit with many knobs and buttes; (3) Completely dissected units with few knobs. Figure 2 only presents units 2 and 3. The unit 3 is always at elevation lower than the unit 1 (sketch of figure 1). This difference is of the same order of magnitude than the width of knobs on unit 2, several tens of meters. On other hand, knobs are never more elevated than the surface of unit 1. These observations confirm the assumption that these units corresponds to three different stages of dissection. In agreement with this assumption, there is a difference of roughness between unit 1 and 3 showing that the dissected unit 3 has different surface characteristics than unit 1. Furthermore, unit 3 on figure 2 is not completely dissected because several “coffee grains” shaped knobs are present. These small knobs are less elevated than nearby knobs of unit 2 and show a central depression. They can be considered as collapsed knobs at the transition between unit 2 and 3. However, such knobs may not be present everywhere at the transition between these two units. We also observe on both figure 1 and 2 several preferential lineations in the direction of the dissected units. This is especially the case on figure 2 where the network of knobs is distributed in an orthogonal pattern. These directions may come from the flow of the icy debris apron but they seem to have an influence in the dissection process. Finally figure 3 summarizes in a schematic 3D representation the different units. It clearly proposes that unit 3 is at the end of a process of dissection. This process generates firstly pits and

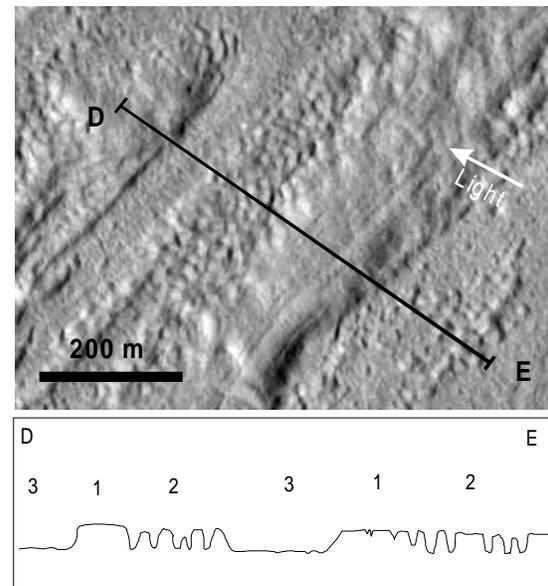


Fig. 1: Close look to MOC image #fha1072 (Coord. 45N, 322W) corresponding to the surface of a lobate debris apron. The sketch represents an interpretative unscaled topographic cross-section through the different units detailed in text.

troughs usually following main directions inside unit 1. In unit 2 these pits become coalescent and create a network of knobs. Collapsed knobs are at the transition between the knobby unit 2 and the rough final surface of unit 3.

Interpretation: All these observations can be explained by the single process of sublimation of ground ice. Indeed lobate debris aprons and fretted channels contain an ice-rich material that explains their convex shape and lineated structures. At the latitude at which they are observed of 35 to 50°, ice is not stable at surface [4]. A thickness of ground of 10 to 30 meters may be affected by sublimation at these latitudes over durations of several hundred million years [4]. This process may explain most of the landforms observed. Usually, thermokarst formed by sublimation develops following a random organization that is not observed here. However, the organization observed in this case corresponds to the orthogonal pattern of fracturation and lineation due to the flow. Such pattern is usually observed in terrestrial pure ice glaciers. The longitudinal trend of fractures is due to the downward flow and lateral fracturation is observed orthogonal to the flow. Thus, these fractures produce heterogeneities in the subsurface accelerating the process.

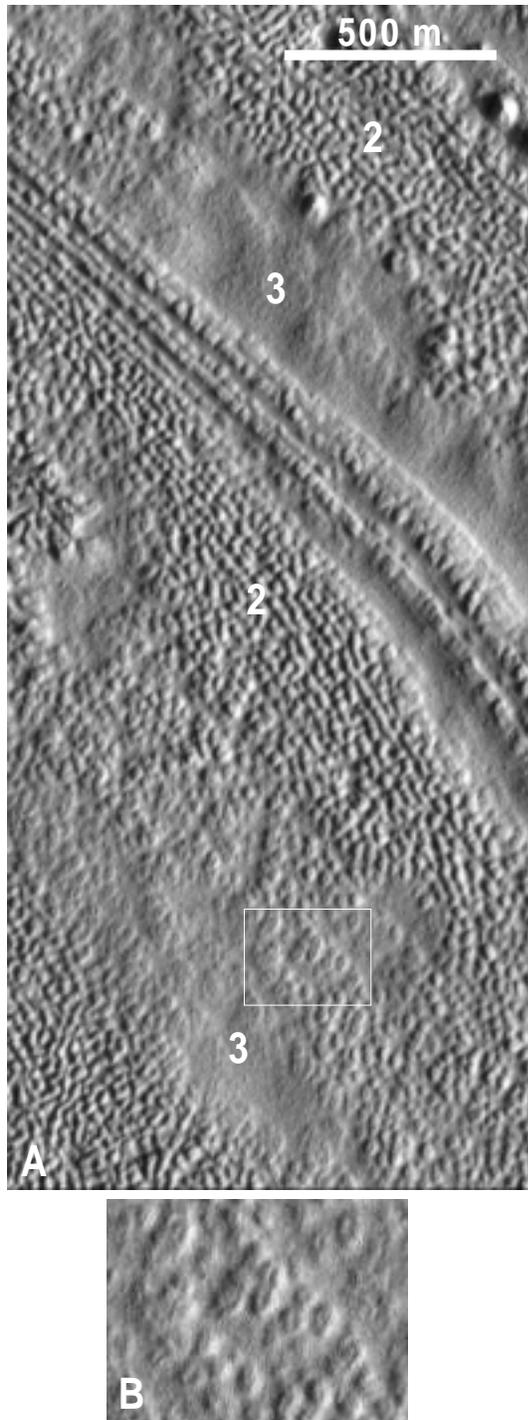


Fig. 2: MOC image #52106 (Coord. 40.5N, 306W). Surface of a lobate debris apron highly affected by knobby unit 2. The sketch B represents “coffee grains shaped knobs” that may correspond to a transitional stage between unit 2 and 3.

Indeed, fractures give a surface of contact between ground ice and atmosphere. The sublimation is then more active than in the porosity of the ground where the size of voids limit the sublimation rate. While ice sublimates, rocks are no more cemented and fall inside the fractures. Then fractures become larger and larger until the isolation of knobs (Fig. 4b). The transition between second and third stage may be explained by the conjugate role of sublimation and relaxation of ground ice inside knobs (Fig. 4c). The final dissected unit (Fig. 4d) presents a roughness different to that of unit 1 because of the boulders and debris produced by such process.

Finally, the thermokarstic dissection of the surface of lobate debris aprons by sublimation of ground ice explain all characteristics of the described landforms like the main directions of dissection or the difference of roughness.

References: [1] Carr M. H. (1996) *Water on Mars*, Oxford Univ. Press. [2] Squyres S. W. (1978) *Icarus*, 34, 600-613. [3] Mangold *et al.* (2000) *LPSC 31th* [4] Fanale, J. R. *et al.* (1986) *Icarus*, 67, 1-18.

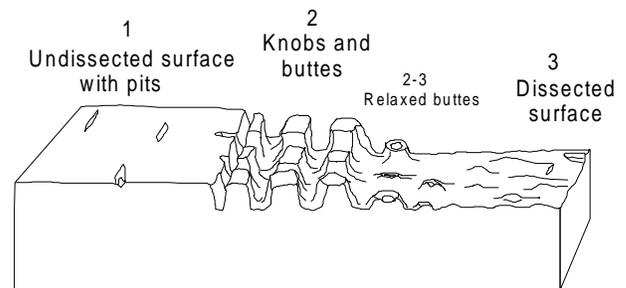


Fig. 3: Synthetic 3D sketch of the different units observed on debris aprons.

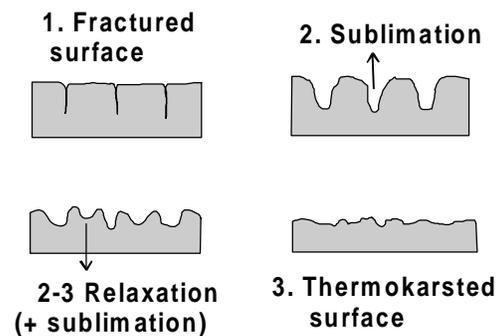


Fig. 4: Evolution of the surface of lobate debris aprons and fretted channels by sublimation of ice facilitated by large fracture network due to ground ice deformation.