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Ice flow in the deepest part of Mars: the banded terrain in Hellas basin.

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Abstract

The morphometric, mapping, and high resolution 3D analyses performed in this study reveals that the banded terrain, which is located in the deepest part of Mars, may have formed through surface or sub-surface viscous flow. The presence of multiple periglacial landforms throughout the banded terrain suggests the presence of ice in the whole subsurface. The Viscous flow hypothesis is supported by a strong link to the topography and to the multiple interactions between the bands.

1. Introduction

The Hellas basin located in the southern hemisphere (centred at 40.8°S, 67.8°E) is one of the largest basins on Mars and the deepest region (depth > 7.5 km) as well. This basin contains multiple geologic units [1]. The NW part of Hellas hosts an enigmatic unit commonly named “banded terrain” [2, 3] (Figs. 1 and 2). The aim of this study is to characterize the particular flow structures of the banded terrain using morphometric and mapping analysis and gain insight into the formation mechanism through 3D views. We used images from the Mars Reconnaissance Orbiter Context Imager (CTX, resolution 6m/px) [4] and the High Resolution Imaging Science Experiment (HiRISE, 25–50 cm/px) [5] in addition to high resolution Digital Terrain Models (DTMs) generated from both datasets.

1.1 Architecture of the banded terrain and interactions with the landscape

Mapping and morphology of the banded terrain: The banded terrain is located in the lowest part of the interior of Hellas where deposition spans the Late Noachian to the Early Amazonian with the final deposition of the banded terrain approximately 3 Gyr ago, age determined by crater-size frequency analysis [2, 3]. The banded terrain itself covers a large (35–42°S, 51–60°E) in the NW of the Hellas basin. This terrain is made up of 3–15 km-long bands that are 90–1,000 m-wide with smooth changes in direction [2]. The bands display shapes that vary from linear to concentric forms (Fig. 1).

Morphometric analysis: Linear and lobate bands are located on the NW downslope of the Alpheus Colles plateau whereas the concentric bands are present in local depressions. MOLA slope and elevation profiles along given linear bands and perpendicular to lobate bands reveal that they are located on slopes of 7° on average. Interestingly, both linear and lobate bands terminate mainly on slopes ~ 2° (Fig. 1). Analogous profiles along the long and the short axes of the concentric bands clearly show their preferential location in depressions rimmed by a crest or a ridge (Fig. 1). Using HiRISE and CTX DTMs within Arcmap 10.1, a minimum thickness of 12 m has been determined from the bands.

2. Banded terrain: viscous flow of an ice-rich material

Multiple periglacial landforms: Many periglacial landforms (Fig. 3) are visible and laterally extensive in the banded terrain. These landforms include polygons with different sizes and elongated pits, scalloped depressions, isolated mounds and structures informally named an “collapse annuli”. Thermal contraction cracking combined with the sublimation of ice in the subsurface are known to form similar periglacial landforms on Mars [2].

Clear geomorphologic signs of viscous flow: 3D views (Fig. 2) obtained from CTX and HiRISE DTMs using ArcScene 10.1 reveal that the morphology of some of the linear and lobate bands is

strongly controlled by the surrounding topography. Multiple directional and morphologic changes of bands are linked to the interaction with the surrounding bands (Fig. 2).

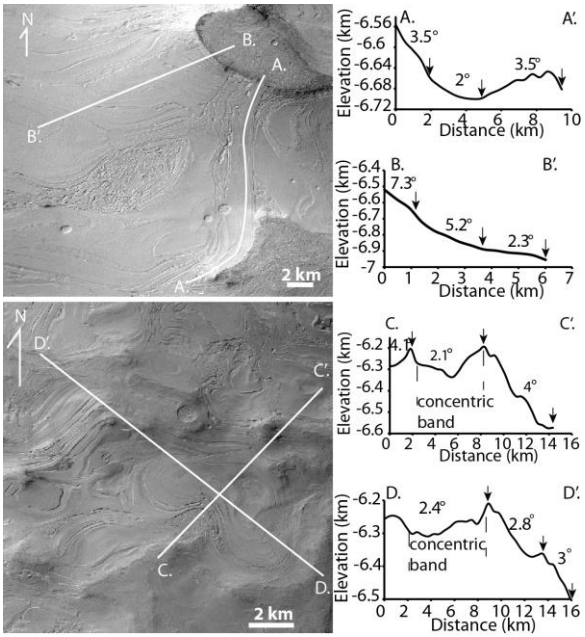

Fig. 1. (***Upper***) linear and lobate bands observed with the CTX camera (profiles AA'-BB'). (***Lower***) concentric bands observed with the CTX camera (profiles CC'-DD'). Image ID: (***Upper)*** P15_006924_1406, (***Lower***) P17_007557_1386.

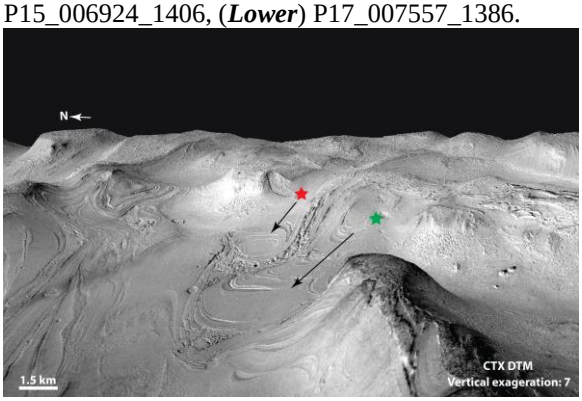

Fig. 2. 3D view from a CTX DTM (image pairs B18_016642_1371 – P18_007913_1371) presenting the competition, direct interaction between a lobate (green star) and a linear (red star) bands.

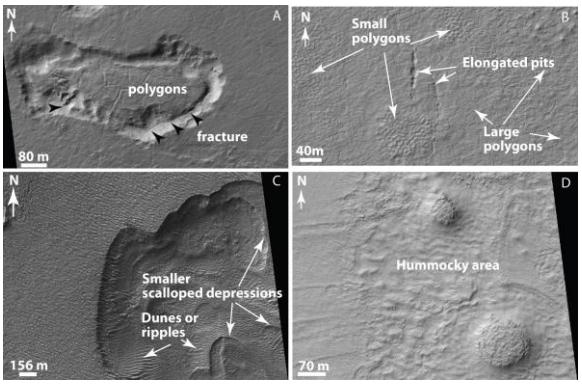

Fig. 3. High resolution images of periglacial landforms in the banded terrain. (A) Elongate rimless collapse annuli. (B) Small and large polygons with an N–S oriented chain of pits. (C) Example of scalloped depressions. (D) Fractured mounds. Image ID: (A) PSP_007781_1410, (B) PSP_007570_1415, (C) ESP_017565_1400, (D) PSP_006568_1415.

6. Summary and Conclusions

The banded terrain appears to be the youngest deposition of Hellas. Morphometric and 3D analyses suggest that the banded terrain may be the result of viscous flow controlled by the topography and the competition of the flow of the adjacent bands. The presence of periglacial landforms in the banded terrain suggests an ice-rich composition for this flow.

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