



# Windows of old fractured crust and associated volcanism in Tharsis, Mars

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## Abstract

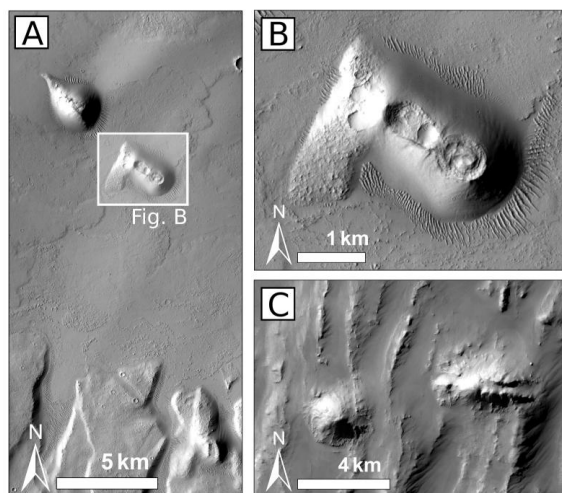
This study investigates older heavily fractured crust in the Tharsis region on Mars, which represents windows to Martian evolution. We observe small positive landforms associated with fractured crust. These edifices seem to be similar to pyroclastic cones that form an unique volcanic field in the southern Ulysses Fossae. We conclude that the edifices studied here are also volcanic in origin and that they are associated with fractured crust. They possible represent remains of earlier volcanism which were later mostly buried under newer lava material covering current surface.

## 1. Introduction

The surface of Tharsis is today mostly covered by young volcanic material produced by plain-style volcanism ([1], [2]) or by eolian deposits e.g. [3]. However, several areas formed by old fractured crust (e.g., Ulysses Fossae; see companion abstract [4], this conference) represent possible windows to the Martian history [5] before the last stage of widespread low-viscous lava activity covered huge parts of Tharsis. Our investigation is focused on these old crustal windows, several of which are heavily fractured by series of crossing-cutting or parallel faults. Faults represent weak crustal zones which enable easier migration of magma from source regions to the surface (e.g., as dikes). Therefore, it seems possible that these areas preserve a record of volcanic eruption styles from earlier periods in Martian history. This assumption is in agreement with our first observation of several heavily fractured areas (Ulysses Fossae, Noctis Fossae, Claritas Fossae), where we distinguish clusters of small positive conical edifices associated with fractured crust (**Fig. 1**). Our main goal is to investigate each fractured region and identify possible volcanic landforms located in these areas for future studies.

## 2. Data

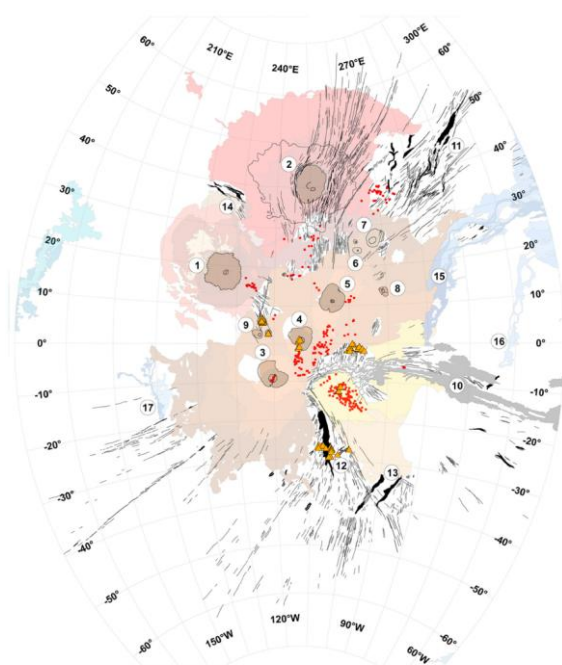
In this study we used data from different cameras orbiting Mars. Our primary sources were CTX images with resolution around 5-6 meters/pixel and HRSC images with resolution of typically 12-20 m/pixel. They were supplemented by HiRISE images to resolve details of investigated edifices in high resolution. We also use MOLA and HRSC DEM for topographic measurements.



**Figure 1:** Several examples of investigated edifices. A) Note old fractured crust in southern part of image and younger lava flows covering older surface. Two conical edifices are standing above younger lava flows (CTX B02\_010318\_1799\_XI\_00S098W, centered 0.17°S/98.83°W) B) Detail of cone with well-developed central crater. C) Another examples of positive edifices with linear central vent associated with heavily fractured terrain partly filled by dust (CTX B20\_017439\_1503\_XN\_29S106W, centered 27.88°S/107.12°W).

### 3. Results

Our results suggest the presence of clusters of small edifices with positive topography (**Fig. 2**), probably of volcanic origin. They may represent the results of monogenetic volcanism, such as cinder cones or spatter cones. The observed cones are generally only few kilometers wide and relatively low in height. Several of them display a central crater on the top of the cone, however in some cases the central crater is missing. Generally these cones are associated with local tectonic features (mostly extensional fractures). In one case we also observe a well-developed small shield volcano which fills a wider depression in fractured crust. Similar edifices are also located on the slope of Pavonis Mons and in the caldera floor of Ulysses Patera, however these features are not associated with visible fractures and we listed here for complexity.



**Figure 2:** Map of Tharsis region with marked centers of possible volcanic edifices associated with old fractured crust (orange triangles) and with low shield volcanoes (red squares). Modified image from [2].

### 4. Summary and Conclusions

At least three regions in Tharsis (in particular Noctis, Ulysses, and Claritas Fossae) contain several clusters of small positive edifices associated with fractured

crust. We interpret them to be volcanic of origin, similar to a volcanic field near Ulysses Fossae [4], which we studied in detail. The clustered edifices seem to be controlled by the local tectonic setting. However we noted that these are preliminary results and spreading of small volcanic features should be possible wider on Martian surface. Our results are potentially important because the study of monogenetic volcanoes represents a tool that can help to localize buried magma-feeding structures ([6] and references therein), and also provides insights into the rich volcanic history of Mars.

### Acknowledgements

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