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Subsurface Investigation over Elysium Planitia, Mars using SHARAD data

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Abstract

Elysium Planitia lies at the boundary between the southern highlands and northern plains. This region has been in the spotlight due to a discussion of whether its origins are fluvial or result from liquid lava. One explanation of its origin is that it was formed by fluvial processes and a frozen sea is buried under a thick dust cover. The other argument is that this region is formed by lava flows. Paleo-channels are claimed to have been found buried underground near Marte Vallis, east of the Western Elysium Basin. However, a comprehensive investigation of subsurface features in this region has not yet been carried out. In this study, we investigate subsurface features using Shallow RADar (SHARAD) radargrams covering this region with an automated pipeline. Secondly, we compare the location of subsurface features with surface images to assure that the extracted features from SHARAD data are from subsurface. According to this comparison, two buried craters are suspected to be identified among the extracted subsurface reflections.

1. Introduction

The Elysium region of Mars lies at the dichotomy boundary transition between the old, heavily cratered southern highlands and the younger northern plains. The region is dominated by compressional (wrinkle ridges), extensional (fractures) tectonic features and broad flat plains [1]. South of the Elysium rise, a broad flat basin was filled by a fluvial channel that originates at the westernmost fractures, the Cerberus Fossae, in Athabasca Valles. The channel is over 10 km wide, contains kilometre-scale streamlined islands and extends more than 300 km from Athabasca Valles to the basin. The Cerberus Fossae, is also proposed to be the fluvial source that carved Marte Vallis to the east [2]. The surface of this area is extremely young (less than 10 Ma old) while it is not uniform in age, as multiple events are testified by overlapping flows, presence of secondary craters and variations in crater density.

Several regions in the Elysium region of Mars have previously been investigated using SHARAD data. Balme et al. [1] discussed the typical terrain in the Western Elysium Planitia ("frozen sea" region) and mentioned that this typical terrain is not restricted to this region and can be traced to a much larger area. Morgan et al. [2] reconstructed paleo-channels in the east of Elysium Planitia, around the Marte Vallis. South of the main western Elysium basin, Alberti et al. [3] used a two-layer model to invert the dielectric constant over the Planitia region and Zephyria Planum (ZP), and found that the relative dielectric constant for the top most layer material is 3 in the ZP and about 3.6-3.8 over three other sites in the Planitia region. Pietro et al. [4] identified at least three main different fluvial units corresponding to three main wet phases and stratigraphic sequences pointing to several deposition-erosion cycles around Zephyria Planum.

Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) [5] and SHARAD [6], are two complementary radar instruments which were launched to investigate the upper crust of Mars and search for subsurface features associated with water and ice. They are orbital sounding radar, that transmits low-frequency radar pulses and is capable of penetrating below the surface. The radar pulse is reflected from where there is a subsurface dielectric discontinuity. Compared to MARSIS, SHARAD has a higher range resolution (15 m vs 150 m for MARSIS) but shallower penetration depth (1 km vs 3 km for MARSIS in the Martian north pole).

In this study, an automated pipeline based on a Continuous Wavelet Transform (CWT) is applied for extracting subsurface layers from SHARAD data over the Elysium region of Mars, including the suspected frozen sea region and the region east in Marte Vallis.

2. Study site and dataset

In this study, we investigated the broad and flat plains in the Elysium region, including the main Western Elysium basin (Area A), Marte Vallis (Area C) and the area between them (Area B). In these three study sites, 141, 189, 151 SHARAD radargrams are collected and processed, respectively for A, B & C.

3. Preliminary Results

We extract the subsurface reflections from the SHARAD data over area A, B and C independently using the proposed pipeline based on CWT [7] and then calculate their depths to the surface DTM. The depth map is shown in Figure 1, from which we can see there are two locations (indicated by red ellipses) which appear like buried craters or basins with deeper buried subsurface reflections than the surrounding reflections. These features have no surface manifestation in the High Resolution Stereo Camera (HRSC) imagery. The HRSC images in the red rectangle are shown in Figure 2.

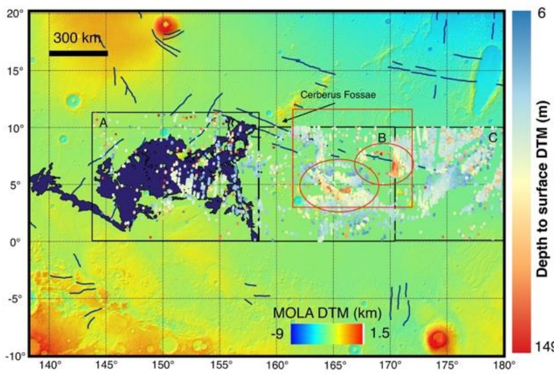

Figure 1: Study sites in Elysium Planitia region. Short dark blue lines are fractures. HRSC image of the red rectangle is shown in Figure 2.

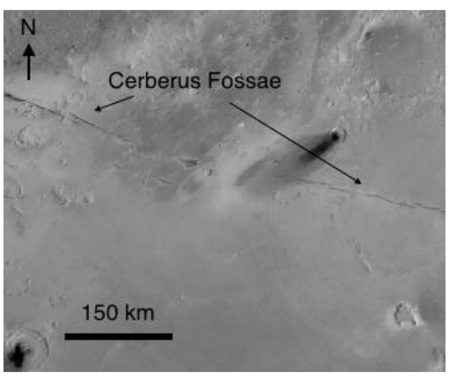

Figure 2: HRSC image (HD263_0000_ND3).

4. Discussion and Conclusions

In area A, there are not many subsurface reflections and their distribution follows no obvious pattern. East of the "frozen sea", more subsurface reflections can be found, such as in area B and C. The ellipse within area B indicates a feature which appears like a buried crater and a half-buried crater can be found next to it. The ellipse at the border of area B and C is over the east part of Ceberus Fossae, north of which there is a half-buried crater. We suspect that these two sites with deep buried subsurface layers are buried craters.

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