SPECTRAL MAPPING OF THARSIS MONTES OF MARS USING CRISM AND THEMIS DATA

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Introduction: The present study is based on the use of remote sensing to determine the surface composition of the Tharsis region of Mars. Two sets of data have been used- Visible- Infrared reflectance data (0.37-3.9 µm) obtained from CRISM on board Mars Reconnaissance Orbiter and emissivity data (6.78-14.88 µm) from THEMIS on board Mars Odyssey. These two datasets have the highest spatial and spectral resolution (CRISM) to study the surface composition of Mars. Both these datasets have been used for spectral and image analysis for the three shield volcanoes of Tharsis Montes. The analysis of the caldera and flank region of these volcanoes indicates presence of significant amounts of hydrated silicates in the form of phyllosilicates while the rocks are mostly showing mafic minerals indicating basaltic composition.

Study Region: The region taken up in this study is Tharsis Montes which is considered to be the most significant geological feature of Mars with respect to the planet evolution, tectonism and geologic timescale. This region is a volcano-tectonic province, and consists of three large shield volcanoes[1]. From northeast to southwest, the volcanoes are Ascraeus Mons, Pavonis Mons, and Arsia Mons. (Figure 1).

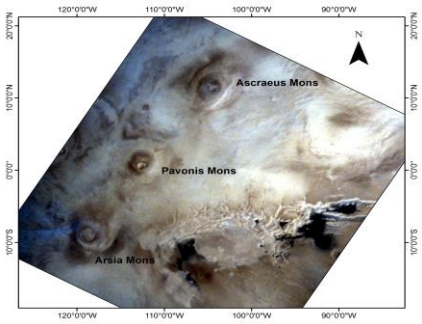

Figure 1:MCC image of Tharsis Montes.

The Mons lie along the dichotomy boundary in Mars' western hemisphere and are spaced approximately 700 kms along a north-eastern lineament within the Tharsis province [2].

Dataset and Methodology: The data used in this project focusses mainly on the summit caldera and flank regions of each of the volcanoes. The satellite data from the CRISM on board MRO has been obtained as MTRDR product(Figure 2A, 3A, 4A) [3]. The second set of datasets has been obtained from THEMIS aboard the Mars Odyssey. The map projected THEMIS output images include emissivity, temperature and radiance data (Figure 5A). The data focused in this study were THEMIS radiance and emissivity data of the caldera regions of the Tharsis Montes having an average surface temperature of more than 240K[4]. Mineralogical analysis was carried out for the three mons of the Tharsis using hyperspectral image analysis. CRISM datasets were processed using standard image analysis techniques. Band ratio techniques were used for CRISM datasets to derive a number of images collectively known as CRISM summary products. RGB combinations using various CRISM summary products alternatively known as CRISM browse products were derived to interpret the mineralogy and lithology of the region[5]. Among the wide range of minerals present, for each region, the focus has been concentrated to find mostly pyroxene group of minerals, olivine and altered minerals like serpentine.

THEMIS data was also processed and analyzed using the ENVI software. The emissivity data of THEMIS were obtained as DCS in the RGB with the corresponding band 8-7-5[6]. The spatial variation of DCS shows that there could be concentration of minerals with high silica content in areas with yellow colour while the areas with blue coloration indicates the presence of minerals with low silica content[7].

Result: The spectral analysis of the CRISM images (Figure 2A, 3A, 4A) on rim of the caldera and flank regions showed absorption features at 1µm, and 2.0 µm demonstrating the presence of minerals like olivine and pyroxenes indicating mafic lithology as suggested by previous researchers[8].

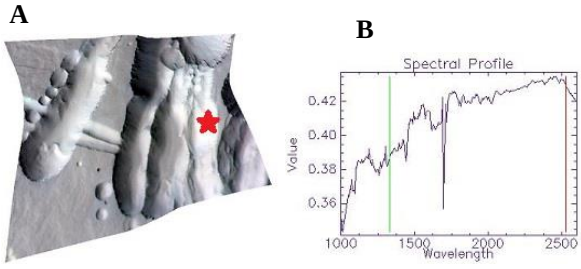

Figure 2: A) MRO-CRISM image FRT000074b4
B) spectral profile of targeted region

Analysis of THEMIS data using band ratio technique validated the same (Figure 5B). However, on detailed analysis of the spectral characteristics from CRISM images suggested alterations of mafic minerals showing absorption peaks at 1.45 µm, 1.7 µm and absorption doublets and triplets at around 2.2 µm (Figure 2B, 3B,

4B). The spectral analysis based on absorption characteristics of individual pixel points collected based on index mapping for olivine and low calcium pyroxene indicate altered pyroxenes and altered olivine rather than presence of minerals like chlorite and serpentine in the phyllosilicate group indicating a continuing alteration process.

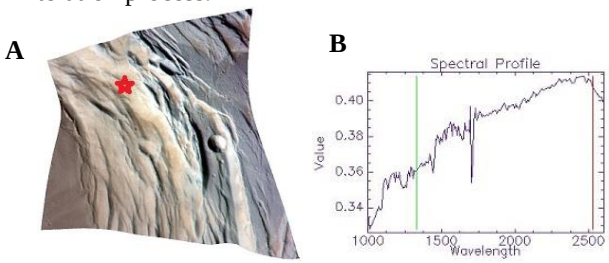

Figure 3: A) MRO-CRISM image FRT0000681f B) spectral profile of targeted region

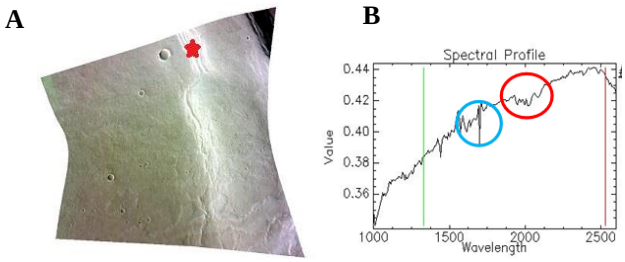

Figure 4: A) MRO-CRISM image FRT0000754e B) spectral profile of targeted region

Conclusion: The result obtained by analyzing the CRISM images gives a fair idea about the mineralogical distribution along the caldera regions of the three shield volcanoes. From analyzing both CRISM and THEMIS data of the Tharsis Montes, the region is identified to be mostly composed of mafic lithology. The identification of basaltic lithology confirms the active status of these volcanoes in the past. Moreover, presence of phyllosilicates and other altered minerals confirm the presence of various hydrated minerals. Thus, its presence could signify the presence of water in this region. The MTRDR dataset used in this study has been observed to contain more noise component as compared to TRDR images.

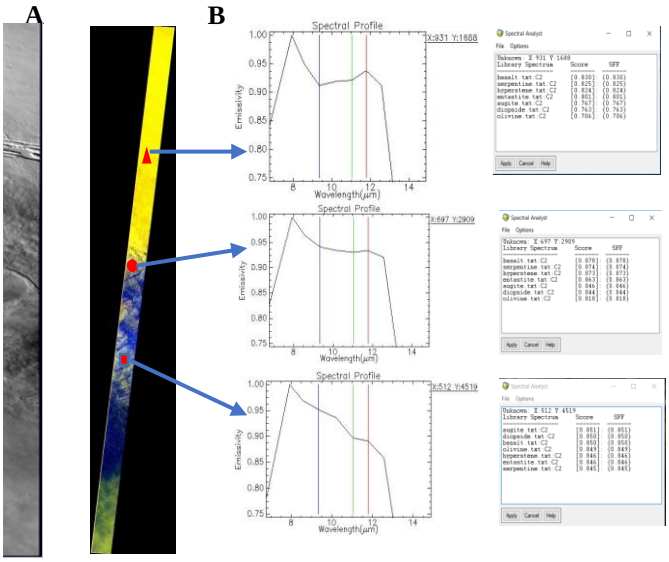

Figure 5: A) THEMIS image I01277008 B) Spectral profiles of three points of interest in THEMIS DCS image I01277008 with spectral analysis score.

Acknowledgments: The hyperspectral dataset has been downloaded from the PDS website (https://ode.rsl.wustl.edu/mars/).

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