Altered Silicate Minerals on Arsia, Pavonis and Ascraeus Mons of Tharsis Volcanic Provinces of Mars

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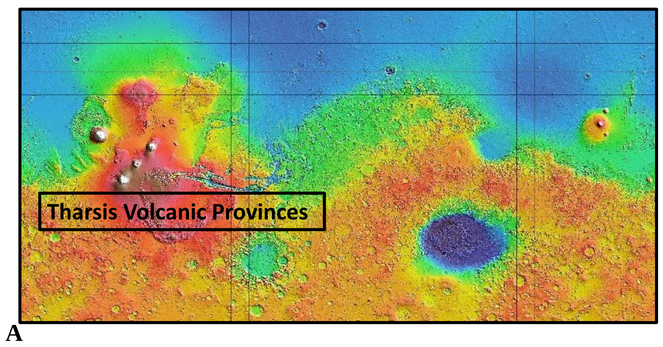
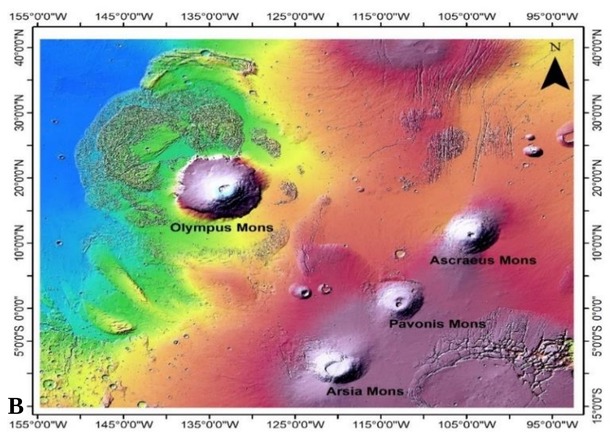
INTRODUCTION

Three shield volcanoes aligned SW-NE: Arsia mons (Figure 1: A, C and F), Pavonis mons (Figure 1: A, D and G) and Ascraeus mons (Figure 1: A, E and H) are large shield volcanos located in Tharsis Volcanic Provinces (Figure 1: A and B) of planet Mars. In the present study, reflectance data of MRO-CRISM (Figure 1: F, G and H) was used to map silicate mineral pyroxene in Arsia chasmata, a steep sided depression located in the northeastern flank of Arsia mons and in caldera region of Pavonis and Ascraeus mons. The presence of these minerals provides the evidence for origin and formation of the Tharsis provinces. Pyroxene minerals outcrops found in early-Noachian to mid-Noachian period must be exposed by erosion from mantle [1]. The ancient Noachian aged units suggests that the deposits were derived from a mantle depleted in aluminum and calcium [1]. Viking Orbiter data suggests that Arsia mons, Pavonis mons and Ascraeus mons had similar evolutionary trends [2]. OMEGA on Mars Express earlier found LCP and HCP on surface of Mars [1][3].



A



B

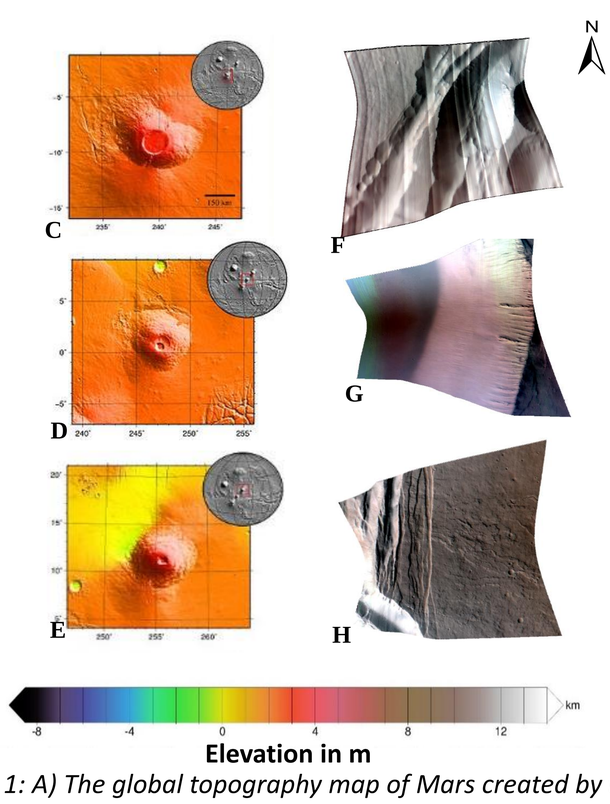
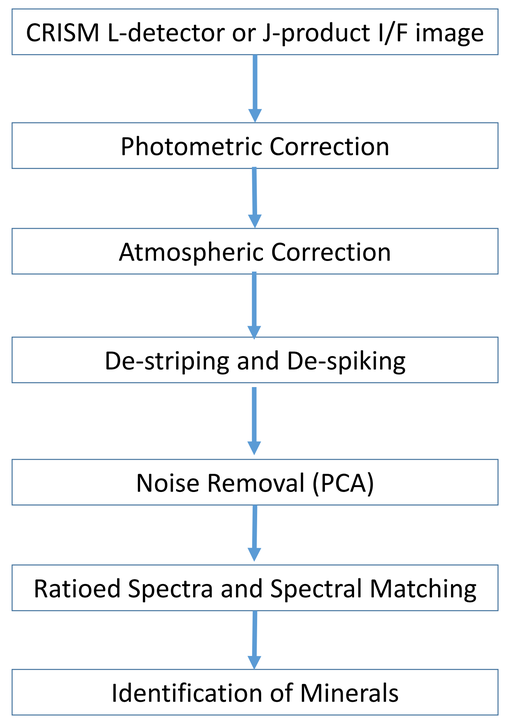


Figure 1: A) The global topography map of Mars created by the Mars Orbital Laser Altimeter (NASA/JPL/GSFC) shows location of Tharsis volcanic province; B) Location of study area within Tharsis volcanic provinces created using MOLA; C, D and E) Location of Arsia mons, Pavonis mons and Ascraeus mons respectively created by MOLA (NASA/JPL/GSFC); F) MRO-CRISM image from Arsia chasmata, Arsia mons: FRT0000475E; G) MRO-CRISM image from Pavonis mons: FRT00006DB6. H) MRO-CRISM image from Ascraeus mons: FRT000123CD.

MATERIALS AND METHODOLOGY

MRO (Mars Reconnaissance Orbiter)- CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) reflectance dataset (Figure 1: F, G and H) have been used to identify minerals on the Tharsis Montes. CRISM TRDR Hyperspectral data set of Arsia mons (FRT0000475E), Pavonis mons (FRT00006DB6) and Ascraeus mons (FRT000123CD) were downloaded from PDS website. Following methodology flow followed in image processing.



RESULTS AND DISCUSSION

After following standard CRISM methodology for CRISM images FRT0000475E (Figure 2:A), FRT00006DB6 (Figure 3:A) and FRT000123CD (Figure 4:A), silicate mineral pyroxene have been identified. Pyroxenes are important group of rock forming inosilicate mineral found in igneous rock. Pyroxene comprises the most dominant component of the igneous Martian crust [4][5].

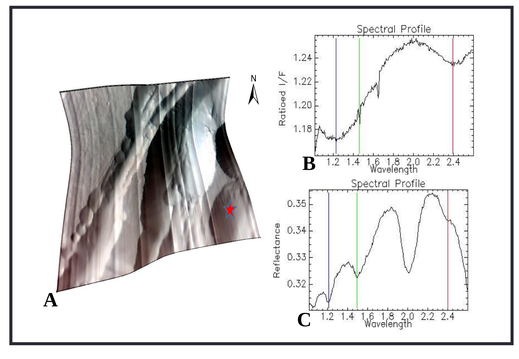


Figure 2: A) MRO-CRISM image FRT0000475E (Arsia mons), B) Ratioed Spectra of Clinopyroxenes (targeted region: red) and C) Reflectance Spectra of Clinopyroxenes (targeted region: red).

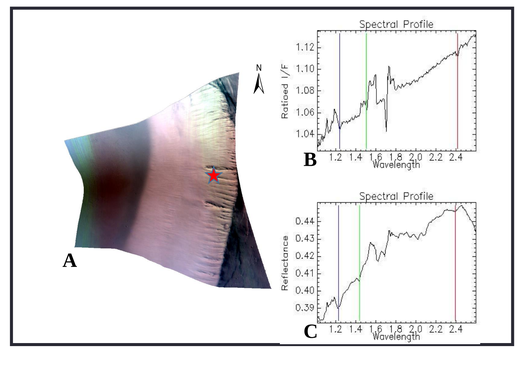


Figure 3: A) MRO-CRISM image FRT00006DB6 (Pavonis mons), B) Ratioed Spectra of Clinopyroxenes (targeted region: red) and C) Reflectance Spectra of Clinopyroxenes (targeted region: red).

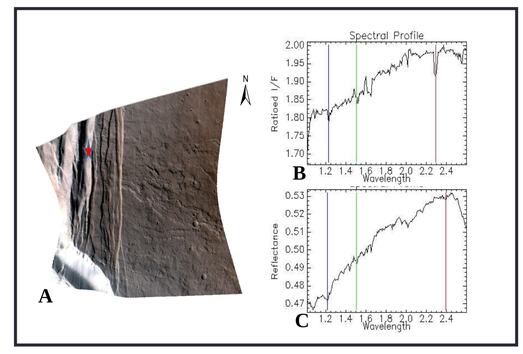


Figure 4: A) MRO-CRISM image FRT000123CD (Ascraeus mons), B) Ratioed Spectra of Clinopyroxenes (targeted region: red) and C) Reflectance Spectra of Clinopyroxenes (targeted region: red).

Pyroxenes [$(Ca, Fe, Mg)_2Si_2O_6$] shows two distinct absorptions feature near 1 and 2 µm, where with increasing calcium content the band centers shifts toward longer wavelengths [6]. Pyroxene that crystallizes in the monoclinic system are known as clinopyroxenes. Deposits of clinopyroxenes (HCP) identified in CRISM images FRT0000475E with absorption feature at 1.24 µm, 1.45 µm, 1.65 µm and 2.39 µm, FRT00006DB6 with absorption feature at 1.24 µm, 1.50 µm, 1.70 µm and 2.40 µm and FRT000123CD with absorption feature at 1.24 µm, 1.50 µm, 1.65 µm and 2.30 µm confirming large scale alteration. Mineral alteration takes place due to active weathering and could be of aqueous or non-aqueous type. Confirmation of presence of altered pyroxenes suggest the active role of weathering on the surface of Mars. Jain et al. also confirms presence of pyroxene in Arsia Chasmata in association with the lava flows [7].

CONCLUSION

MRO-CRISM dataset confirms presence of highly altered silicate mineral pyroxene in Arsia chasmata region of Arsia mons and caldera part of Pavonis and Ascraeus mons. Possible explanation of highly altered pyroxenes could be weathering of in-situ basaltic lava material or another extreme possibility of hydrothermal precipitation. To understand formation of minerals, mineral alterations and associated environments, morphological studies are of great help. Hence, an integration of study on mineral alterations and geo-morphology of Tharsis volcanic provinces is important in elucidating the evolutionary history of Tharsis Montes with respect to Mars.

ACKNOWLEDGEMENT

RRP would like to express his gratitude to Space Applications Centre (ISRO), Ahmedabad for the training received under TREES. RRP would also like to thank Mr. Sumit Pathak, SRF, SAC (ISRO), Ahmedabad for his valuable suggestions. AMN would like to acknowledge ISRO MOM for the funding received for her project. All data used in this study are publically available from the NASA PDS.

REFERENCES

[1] Mustard J. F. et al. (2005) *Science,* 307 (5715), 1594-1597. [2] Crumpler and Aubele. (1978) *ICARUS,* 34, 496-511. [3] Mustard J. F. et al. (2008) *Nature,* 454, 305-309. [4] Bandfield et al. (2000) *Science,* 287, 5458 1626-1630. [5] Bandfield (2002) *JGR* 107, E6, 5042. [6] J. B. Adams, *JGR* 79, 4829 (1974). [7] Jain et al. (2014) *LPS XLV*, abstract #1826.