IDENTIFICATION OF ALTERED SILICATE MINERALS ON ARSIA, PAVONIS AND ASCRAEUS MONS OF THARSIS VOLCANIC PROVINCES OF MARS. Raj R. Patel[1] and Archana M. Nair[2], Indian Institute of Technology Guwahati 781039, India, [1](rajpatel.iitg@gmail.com), [2](nair.archana@iitg.ac.in).

Introduction: 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. Absorption features obtained from the analysis are at 1.24 µm, 1.45 µm, 1.65 µm and 2.39 µm in Arsia chasmata region, 1.24 µm, 1.50 µm, 1.70 µm and 2.40 µm in the caldera region of Pavonis mons and 1.24 µm, 1.50 µm, 1.65 µm and 2.30 µm in the caldera region of Ascraeus mons suggesting highly altered pyroxenes. 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]. Very feeble mineralogical analysis are available in the literature for all mons and therefore the present research contribute to understand process of formation and origin of Tharsis province and associated mineralogy.

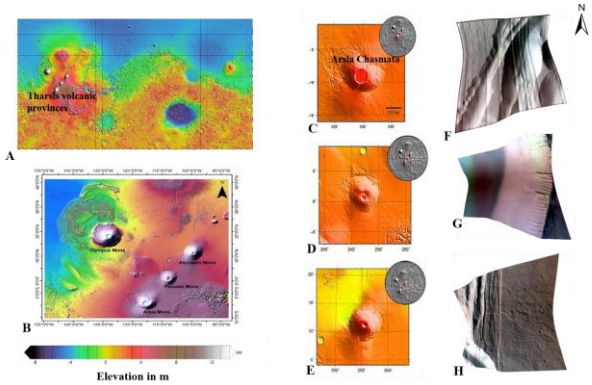

Figure 1: A) The global topography map of Mars created by the Mars Orbital Laser Altimeter (NASA/JPL/GSFC) shows location of Tharsis volcanic provinces; B) Tharsis volcanic provinces along with volcanoes; C) D) and E) Location of Arsia mons, Pavonis mons and Ascraeus mons respectively created by MOLA (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.

Study Area: Tharsis volcanic provinces of Mars represents a continent sized region of anomalously elevated terrain which contains largest volcanoes in the solar system. Three shield volcanoes aligned SW- NE Arsia mons, Pavonis mons and Ascraeus mons collectively known as Tharsis montes. Viking Orbiter data suggests that Arsia mons, Pavonis mons and Ascraeus mons had similar evolutionary trends [2]. Various geomorphological units have been found in all mons such as lava flow, grabens and shield of caldera, etc. [3][4]. Present study focuses on mineralogy in Arsia chasmata and caldera of Pavonis and Ascraeus mons especially for silicate mineral pyroxene. Earlier OMEGA on the Mars Express spacecraft identified rock forming mineral low-calcium pyroxene (LCP), and high-calcium pyroxene (HCP) on the surface of Mars [1]. Low-calcium pyroxene (LCP) also found in Nili Fossae region of Mars [5].

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. CAT (CRISM Analysis Tool) in ENVI software was used to analyze CRISM dataset. CAT is an effective tool which removes photometric correction, atmospheric correction and also data filtering. To analyze spectral signature of minerals, CRISM image in the spectral range of 1.0 to 2.6 µm with 18 to 35 m spatial resolution was used. Ratioed spectra is found by dividing each pixel by least varying spectra in the image to enhance the spectral signature of targeted pixel. Spectral analyst technique was used to match the spectral shape of targeted pixel with minerals available in spectral library.

Results: 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 [6][7].

Pyroxenes [(Ca, Fe, Mg)$_2$Si$_2$O$_6$] shows two distinct absorptions feature near 1 and 2 µm, where with increasing calcium content the band centers shifts toward longer wavelengths [8]. 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 [9].

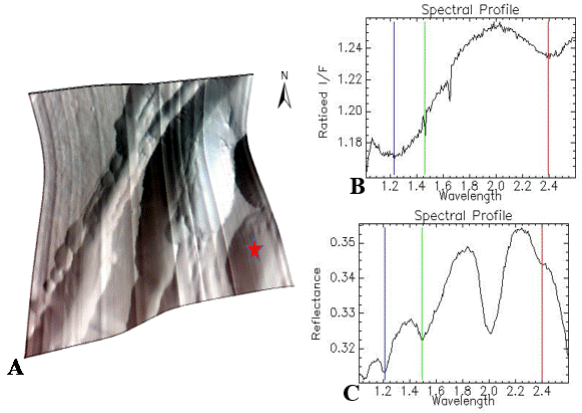

Figure 2: A): MRO-CRISM image FRT0000475E (Arsia mons), B): Ratioed Spectra of Clinopyroxenes (targeted region: red) and C): Reflectance Spectra of Clinopyroxenes (targeted region: red).

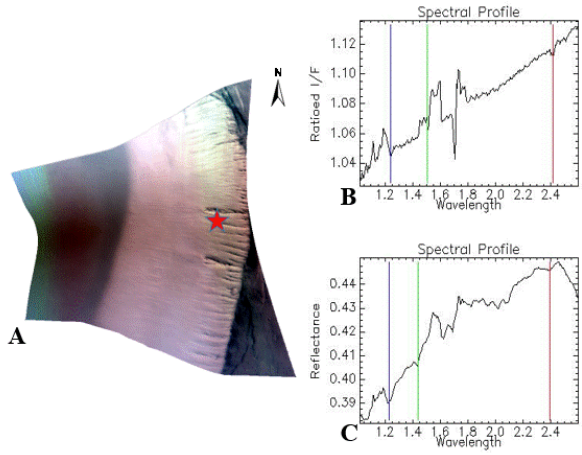

Figure 3: A): MRO-CRISM image FRT00006DB6 (Pavonis mons), B): Ratioed Spectra of Clinopyroxenes (targeted region: red) and C): Reflectance Spectra of Clinopyroxenes (targeted region: red).

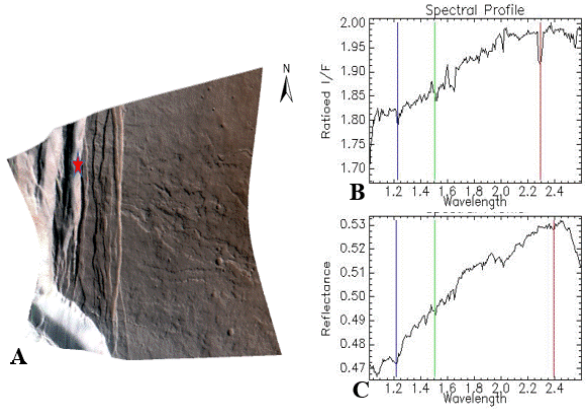

Figure 4: A) MRO-CRISM image FRT000123CD (Ascraeus mons), B) Ratioed Spectra of Clinopyroxenes (targeted region: red) and C) Reflectance Spectra of Clinopyroxenes (targeted region: red).

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 geomorphology of Tharsis volcanic provinces is important in elucidating the evolutionary history of Tharsis Montes with respect to Mars.

References: [1] Mustard J. F. et al. (2005) *Science*, 307 (5715), 1594-1597. [2] Crumpler and Aubele. (1978) *ICARUS*, 34, 496-511. [3] Scott D. H. et al. (1986) National Aeronautics and Space Administration, *U.S. Geological Survey*. [4] Mohr et al. (2016) *LPS XLVII*, Abstract #1550. [5] Mustard J. F. et al. (2008) *Nature*, 454, 305- 309. [6] Bandfield et al. (2000) *Science*, 287, 5458 1626-1630. [7] Bandfield (2002) *JGR* 107, E6, 5042. [8] J. B. Adams, *JGR* 79, 4829 (1974). [9] Jain et al. (2014) *LPS XLV*, abstract #1826.