AQUEOUS MINERALS FROM ARSIA CHASMATA OF ARSIA MONS, THARSIS REGION: IMPLICATIONS FOR AQUEOUS ALTERATION PROCESSES ON MARS. N. Jain*, S. Bhattacharya, P. Chauhan, Space Applications Centre (ISRO), Ahmedabad, Gujarat, India (nirmala@sac.isro.gov.in/ Fax: +91-079-26915825).

Introduction: The Arsia Chasmata is a complex collapsed region located at the northeastern flank of Arsia Mons (figure 1 A and B) within Tharsis region of planet Mars and is the most important region for the study of minerals like phyllosilicate and pyroxene. The reflectance data of MRO-CRISM (figure 1 C D) has confirmed above mentioned minerals in the study area. The presence of these minerals at the Arsia Chasmata on Mars provides the evidence of its past watery environment and their processes of formation. In the present study the absorption features of serpentine (phyllosilicate) are obtained at 2.32 µm, 1.94 µm and 2.51 µm. Previous studies on Mars show that phyllosilicates are the alteration products of basaltic rocks [1]. In present study serpentine has been found in association with volcanic material of Arsia Mons. Therefore, the parent rocks in the study area may be rich in basaltic composition. Much mineralogical studies have not been carried out in eastern flank of Arsia Chasmata. Therefore, this study will contribute to the knowledge to understand the mineralogy and their processes of formation in this area as well as in other volcanic regions on Mars.

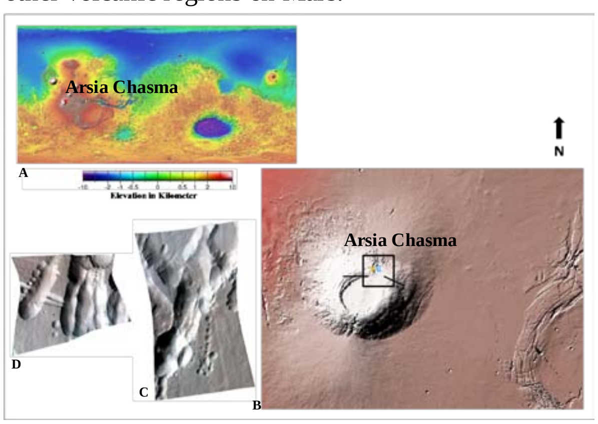

Figure 1: A)- The global topography map of Mars created by the Mars Orbital Laser Altimeter (NASA/JPL/GSFC) shows location of Arsia Chasmata on Arsia Mons in Tharsis area of Mars, B)- Location of Arsia Chasmata on Arsia Mons, C)- MRO-CRISM image HRL0000D074 and D)- MRO-CRISM image FRT000074B4

Study Area: The Arsia Mons is the southernmost volcano of the Tharsis region [2]. Large number of studies have been done for the Western flank of the Arsia Mons than northeastern flank. Different geomorphological units have been found by many researchers in previous studies of Arsia Mons with the help of high resolution data such as MGS-MOC (Mars Global Surveyor-Mars Orbiter Camera), Viking orbiter [3], fresh appearing lava flows [4], graben and glaciers on flanks of Arsia Mons [5], young lava flows [6] small shields at floor of caldera [7].

Present study mainly focuses on the mineralogy of Arsia Chasmata which interestingly contains absorption features of aqueous altered minerals such as serpentine (phyllosilicate). This mineral is also located in Nili Fossae region which is long, narrow depression present on Mars [8]. But in the present study occurrence of this mineral at high altitude region raise the curiosity to know about their formation processes. At this altitude the phyllosilicate may be formed due to chemical weathering of volcanic debris in Martian past [9]. Previous studies identified multiple episode of volcanic and glacial activity with associated hydrothermal water release caused by the melting of subsurface and surface ice by magma intrusion. This hypothesis is applicable for the formation of above mentioned aqueous mineral in the study area. This mineral is strongly linked with the water and past climate history of Mars [8].

Datasets and methodology: Two MRO-CRISM reflectance data (figure 1 C D) from visible to near infrared region have been used for the study of phyllosilicate mineral such as serpentine and silicate mineral such as pyroxene. In the present study the analysis of spectral signatures of Martian minerals have been performed by using 'L' spectrometer of CRISM imager within the range from 1.0 µm to 2.6 µm with spatial resolution 18m to 35m. Study of spectral signatures has been done in ENVI 4.5 software and CRISM hyperspectral data has been analyzed through CRISM Analysis Tool (CAT). The ratioing technique was used for enhancing the spectral signature form pixel of interest. Spectral Analyst technique in which unknown ratioed spectra of the minerals from the study area on Mars was compared with the known spectral signature of minerals from the standard CRISM spectral library.

Results: Deposits of serpentine and pyroxene have been identified in Arsia Chasmata by spectroscopic analysis using CRISM images such as FRT000074B4 (figure 2 A) and HRL0000D074 (figure 3 A). They have been associated with geomorphological features such as lava flows (figure 2 B and 3B).

Identified minerals at study area:

Serpentine: Serpentine (Mg_6 (Si_4O_{10}) $(OH)_8$) is the mineral which forms under the processes such as metamorphism, hydrothermal activity etc on the Earth. Spectral absorption features have been occurred in the Arsia Chasmata region (figure 2 C) at 2.32 μm with absorptions at 1.2, μm, 2.51 μm. Absorption feature at 2.32 μm is due to Mg-OH in serpentine. 1.94 μm shows the presence of H_2O or hydrated phase of serpentine. 2.32 μm, 1.9 μm, 2.51 μm are important bands of magnesium rich serpentine [8].

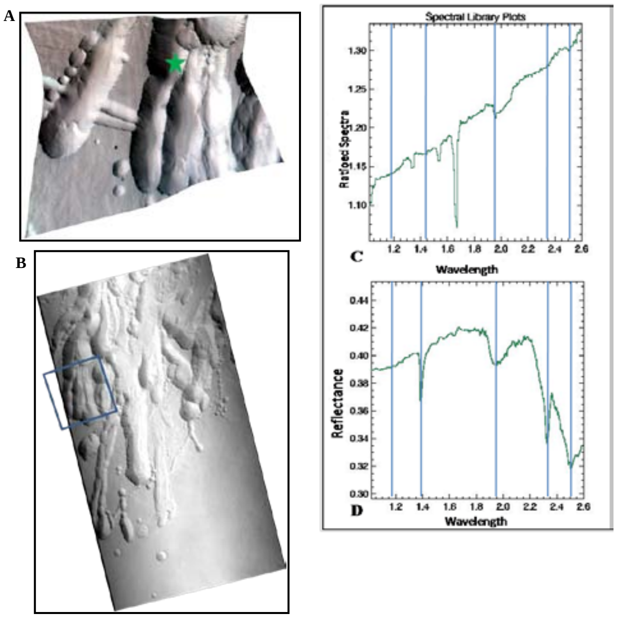

Figure 2: A)- MRO- CIRSM image FRT000074B4, B) -MRO-CONTEXT-B11_013879_1720_XN_08S119W shows location of CRISM image FRT000074B4 (blue), C)- Ratioed Spectra of serpentine (green) and D)- Serpentine LASR22 from CRISM spectral library.

Pyroxene:

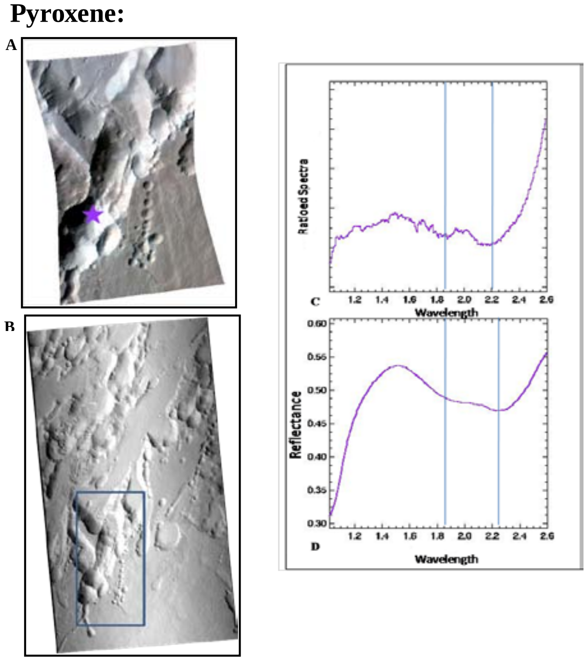

Figure 3: A)- MRO-CIRSM image HRL0000D074, B) -MRO-CONTEXT- 08_012745_1723_XN_07S119W shows location of CRISM image HRL0000D074 (blue), C)- Ratioed Spectra of pyroxene (purple) in study area and D)- Pyroxene C1XP17 from CRISM spectral library.

After comparison of spectral signature of unknown mineral from study area (figures 3 C) with known spectra from CRISM spectral library (figures 3 D), absorption bands such as 1.27μm, 1.44μm, 1.88μm and 2.24μm have been identified in image HRL0000D074 (figures 3 A) which are the important bands of pyroxene.

Conclusions: MRO- CRISM confirms the presence of phyllosilicate (serpentine) and silicate (pyroxene) in Arsia Chasmata in association with the lava flows.

In Arsia Chasmata, the deposits of serpentine and pyroxene are found at place which is present at the top part of chasmata. On the basis of distribution of serpentine over the lava flows we proposed that 1) this mineral could have been formed by the alteration of parent volcanic deposits rich in pyroxene present on the flank of the Arsia Mons by hydrothermal fluid inclusion during volcanism or 2) by weathering of parent material by acid fog or by sulfate rich solution. This hypothesis can test for observations of other places where phyllosilicates are found in volcanic cones in other regions of Mars. In future study, age determination of these exposures is most important in order to know their formation period and past environmental conditions. It will help to know more about the aqueous minerals at volcanic area. Arsia Chasmata is geologically important region for future study to know more about the formation processes of these minerals in volcanic region.

References: [1] William H. F. et al., 2009, Icarus 204 (2009) 478–488. [2] Stephanie C. Werner, 2009, Icarus 201, 44–68. [3] Shean D. E. et.al, 2007, Journal of Geophysical Research, Vol. 112, E03004. [4] Scott D. H et.al, 1986, National Aeronautics and Space Administration, U.S. Geological Survey. [5] Jozwiak L. M. et.al, 2013, 44th Lunar and Planetary Science Conference, 2207. [6] Hiesinger H.et.al, 2008, Lunar nd Planetary Science 1277. [7] Garry W. B. et.al, 2013, 44th Lunar and Planetary Science Conference, 1647. [8] Ehlmann B.L. et.al, 2009, Journal of Geophysical Research, Vol. 114, E00D08. [9] Dicle Bal A, 2009, Ozean Journal of Applied Sciences 2(2), ISSN 1943-2429.