IDENTIFICATION OF DEPOSITS OF AQUEOUS MINERALS IN NORTHERN PART OF HELLAS PLANITIA REGION ON MARS USING MRO-CRISM: IMPLICATIONS FOR PAST AQUEOUS HISTORY OF MARS. N. Jain and P. Chauhan, Space Applications Centre (ISRO), Ahmedabad, Gujarat, India (nirmala@sac.isro.gov.in/ Fax: +91 07926915823).

Introduction: The northern part of Hellas Planitia on Mars hosts the deposits of phyllosilicate. Mars Reconnaissance Orbiter-Compact Reconnaissance Imaging Spectrometer for Mars (MRO-CRISM) has discovered relatively fresh exposures of phyllosilicate in one part of the study area (fig. 1a) which represents presence of past aqueous environments on Hellas Planitia. Near-infrared and short wave infrared spectra of MRO-CRISM extracted from the deposits exhibit broad absorptions at 1.41 μm, 1.92 μm, 2.1 μm, 2.29 μm and 2.31 μm that are most consistent with laboratory spectra of vermiculite. Two absorptions especially the 1.4 μm and 1.92 μm bands show the hydration signatures in the study area, suggesting presence of past water on Mars. We identify the geomorphological context of these minerals using high-resolution data from High Resolution Imaging Science Experiment (HiRISE) onboard MRO in combination with CRISM (fig. 1b and c). These data represent the exposure of layer deposits and mud cracks in association with deposits of phyllosilicates. The altered minerals (phyllosilicates) in the northern part of Hellas Planitia are more important and they have reseled from alkaline environment. These minerals support to study the past aqueous environmental conditions of planet Mars.

Study Area: Hellas Planitia is a plain located within the impact basin Hellas in the southern highlands of Mars. The basin floor is about 7,152 m deep and extends about 2,300 km east to west. It is the largest impact basin on Mars and was possibly formed by a huge impact during the Late Heavy Bombardment of the early Solar System, around 4.1 to 3.8 billion years ago. Therefore it is one of the important preserved early impact basins. Hellas is surrounded by gullies [1], flow features (either fluvial or lava flow), ice, impact craters and mud cracks. Gullies and other landforms could be reason for presence of water. Minerals such as Fe/Mg-rich phyllosilicates, chlorite, Al-smectites/kaolins, prehnite, zeolites, Fe/Mg-micas and carbonates/lizardite were reported in previous studies carried out in northern part of Hellas Planitia using Mars Express (MEx)- Observatoire pour la Minéralogie, l’Eau, la Glace et l’Activité (OMEGA) and Mars Reconnaissance Orbiter (MRO)-Compact Reconnaissance Infrared Spectrometer for Mars (CRISM) in northern part of Hellas Planitia [2]. Different geological units have been mapped in northern part of Hellas Planitia in previous studies. The study area exhibits dendritic valley networks [3] and mud flows.

Figure 1: a) CRISM image shows locations of phyllosilicates (magenta and brown in color), b) and c) HiRISE images show the locations of ratioed spectra taken from corresponding CRISM image, d) and e) Ratioed spectra of phyllosilicates from the study area and f) Spectral signature of phyllosilicates from CRISM spectral library.

In the present study analysis of aqueous minerals associated with geomorphology has been done. Detailed characterization of minerals and their relation with morphological features can be used to better understand the aqueous processes minerals in the study area. Mineralogy has been examined with the imaging spectrometer data of CRISM in the spectral range of 1.0 to 2.6 μm in northern part of Hellas Planitia. We have identified Fe/Mg/Al rich phyllosilicates using data acquired by the CRISM.
Datasets and Methodology: In the present study the analysis of spectral signatures of aqueous minerals from the study area was performed by using hyperspectral data of CRISM in NIR-SWIR region (1.02 μm to 2.6 μm). To reduce the effect of atmospheric CO₂ present in the atmosphere of Mars and to enhance the contrast of surface reflectance from the martian surface, CRISM data was corrected using a volcano scan approach [4], [5] and [6] using the CRISM Analysis Tool (CAT) software. Various image processing techniques were applied on the CRISM data. Farward and inverse PCA has used to reduce the instrumental noise from the CRISM input image and spectral signature of the minerals collected from CRISM data. However, it was observed in CRISM data that a broad CO₂ absorption feature persist in the spectral data even after atmospheric correction. [5] and [7] have suggested using a ratio of mineral spectra with spectra of spectrally flat regions to enhance the absorption features caused by electronic and vibration processes, and this analysis was done. We used the Spectral Analyst tool for spectral mineral matching. The detected ratio spectra of unknown minerals on Mars were compared with the known spectra of minerals from the standard CRISM spectral library. The results have been interpreted for spectral discrimination of minerals and their relationship with geomorphological evidence using high resolution data sets. Geomorphological analysis has been carried out using HiRISE images for identification of the regional geological settings.

Results: The analysis confirmed the presence of aqueous minerals such as vermiculite (fig. 1d and e). Figure 1e was also slightly matched with seprntine. Strong absorption features at 2.1 μm and 2.31 μm indicate presence of phyllosilicates. The presence of 1.1 μm to 1.16 μm could indicate the existence of ferrous iron-bearing mineral. CRISM image (figure 1a) shows a locations of ratioed spectra (magenta and marron in color). CRISM spectra shows broad absorptions centered around 1.41 μm, 1.92 μm, 2.1 μm, 2.31 μm and 2.52 μm. The absorptions near 1.4 μm and 1.9 μm are strong features for water. Spectra from study area was matched with VERMICULITE LAVEO1 of CRISM spectral library (figure 1f: blue in color). The area in CRISM image is located in the part of the ejecta of the impact crater. It comprises different geomorphological features such as the layer deposits, mud cracks, sand dune and impact crater (figure 1b and c). Therefore, the deposits of vermiculite could have been formed by hydrothermal alteration during impact crater processing or circulation of ground water through parent rocks caused by heat of impact. On Earth vermiculite is formed by alteration of biotite and phlogopite during hydrothermal processes. It can also form from alteration of ultrabasic rocks. Study of vermiculite from martian surface is important to understand the alteration of ultrabasic rocks of planet Mars.

Conclusions: Datasets from CRISM and HiRISE on MRO spacecraft have played significant role in understanding the mineralogy and geomorphology of the surface of Mars with its high spectral and spatial resolution quality. Spectroscopic study of northern part of Hellas Planitia area within confirms the presence of phyllosilicates. With the help of these minerals we conclude that, the presence of phyllosilicates implies that water played an important role during their formation period, this study provides information about the past environment conditions of Mars. The study area mainly shows geomorphological features such as impact craters, mud cracks and layer deposits. The presence of phyllosilicates in northern part of Hellas Planitia could have been formed at the time of hydrothermal alteration processes due to impact crater or by weathering of parent rock in the presence of water. Presence of aqueous minerals makes northern part of Hellas Planitia as promising region for the study of aqueous alteration processes for the future studies.

Acknowledgements: We express our thanks to Shri A. S. Kiran Kumar, Director, SAC, ISRO for his enduring support and encouragement in this study. We are also thankful to Dr. P. K. Pal Deputy Director, EPSA, SAC, ISRO for his valuable guidance and support.