GEOLOGICAL INVESTIGATION OF NORTHERN RIM OF ARGYRE PLANITIA, MARS USING HIGH RESOLUTION DATASETS

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Introduction: Exploring Mars using space technology has been one of the primary focuses over the years to understand the composition of planets beyond earth. Numerous missions across the globe have explored the surface, atmosphere, and interior of Mars to redefine human knowledge about this red planet. Mars has gone through various destructive and constructive phases throughout its evolution. Remanence of these periodic incidences are visible on the surface of the planet, therefore exploring these features are important to understand the evolution of the planet.

One of the striking features on the Martian surface are the multi-ring impact basins. They were formed when Mars was impacted by huge basin sized impacts that significantly influenced the morphology and surface composition of its primordial crust. The formation of the impact basin is capable of influencing crustal development and growth, altering the thermal history of the planet. These impacts also induced volcanic activities that caused a major modification on the crustal structures of the planet [1]. The impact dominated the Martian surface during post-Noachian era. Very large impacts have gave rise to Hellas and Argyre multiring impact basins. Argyre Planitia is the second largest impact basin with records of variability of mineralogical and morphological activities. Previous studies have verified that the rim of Argyre Planitia consists of early Noachian-aged excavated units which are composed of basaltic materials [2]. Later detection of olivine, high-calcium pyroxene (HCP), and low calcium pyroxene (LCP) by OMEGA datasets [3] on the early Noachian-aged units mainly in the northern rim raised the key question about the origin of these units. Further investigation verified that the presence of altered minerals is associated with these Noachian-aged units[4].

In the present work, investigation of the Northern rim of Argyre Planitia have been attempted to verify the mineralogy detected by OMEGA analysis for mafic exposures (olivine and pyroxenes) using high-resolution imaging hyperspectral CRISM datasets. Furthermore, these mafic exposures are observed in high-resolution optical data to understand their nature of occurrences and distribution over the basin rim.

Study Area: Argyre Planitia (51^0S and 43^0E) is ~1800 kms highly degraded impact basin present on the southern highlands of Mars. It has a well preserved basin structure (Figure 1), with associated ring structures. Topographical analysis of the impact basin indicates that the total relief of the basin is about 10 km, and the basin floor is smooth and somewhat tilted towards northwest [4], [5]. The geological units associated with Argyre Planitia are spread across early Noachian to Hesperian period. This basin has witnessed several regional modifications that includes erosional and depositional processes mainly from fluvial, eolian, lacustrine activities [2], thus is a potentially ideal probe to study for compositional layering of ancient highlands.

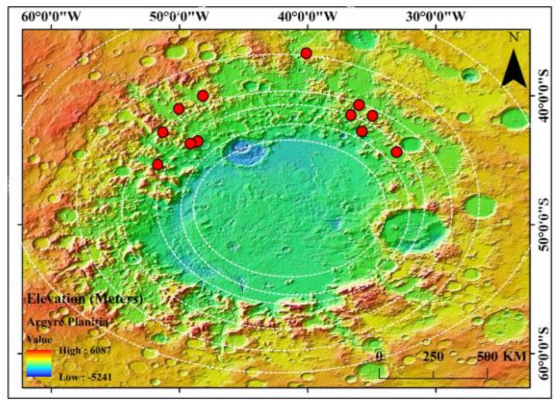

Figure 1 Argyre Planitia basin as observed in MGS-MOLA colour image with seven associated rings [5]. The red dots indicates location of spectra acquired through CRISM analysis.

Methodology: To analyze the Northern rim of Argyre Planitia, hyperspectral dataset from Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard NASA's Mars Reconnaissance Orbiter (MRO) mission was utilized [6]. It has spatial resolution of 18-36m/pixel and spectral resolution of 0.362-3.920µm at 6.55nm/channel sampling over 544 channels. CRISM 'L' detector covers range from 1.0µm to 3.92µm [7]. Noise reduction technique was applied to assist mineral detection in this region. High Resolution Imaging Science Experiment (HiRISE) and Context Camera (CTX) images from the same mission were utilized for observation and mapping. Its 0.5m resolution camera allows the investigation of minute detail within the targeted region [8]. Reduced Data Records which are radiometrically corrected and geometrically mapped, were utilized to pinpoint area for CRISM detected exposures. Besides, data from Mars Orbiter Laser Altimeter (MOLA) data from Mars Global Surveyor (MGS) were utilized for topographical analysis [9].

Results: Analysis of total twelve images of CRISM data indicates olivine-rich lithology in the Northern rim of Argyre Planitia. The olivine-rich areas were identified on the basis of spectral parameter OLINDEX3, which detects board absorption centered at 1μm [10]. Olivine were detected on the basis of three characteristic absorptions near 1.02 μm domain. Further the spectra were subjected to spectral band rationing with a neutral area to normalize the reflectance spectra and enhance the spectral signature. The obtained spectra were compared with spectral library data that indicates the composition of olivine to be more forsteritic (Figure 2). Besides olivine, pyroxenes were detected based on their two broad absorptions around 1 and 2 μm whose band center shows shifting with increasing calcium and iron content. While LCP is centered near 0.9 and 1.9 μm, HCP are centered at 1.0 and 2.3 μm [10]. Initial analysis suggest them to be LCP. When observed in high-resolution images these mafic exposures seems associated with rugged terrain and along sinuous ridges. Detailed Presence of olivine exposures around the rim of the Argyre basin could be the upper mantle material and consistent its tectonic framework and age. It would have been excavated from the subsurface and emplaced as discontinues patches on the Northern terrace zone of the impact basin either through impact or later volcanic activity.

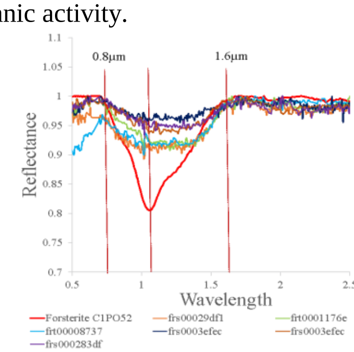

Figure 2 Comparison of normalized spectra of olivine acquired from CRISM data from the study region with spectral library olivine (Forsterite C1PO52)

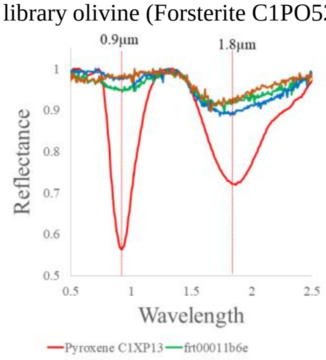

Figure 3 Comparison of normalized spectra of pyroxene acquired from CRISM data from the study region with spectral library pyroxene (CIXP13)

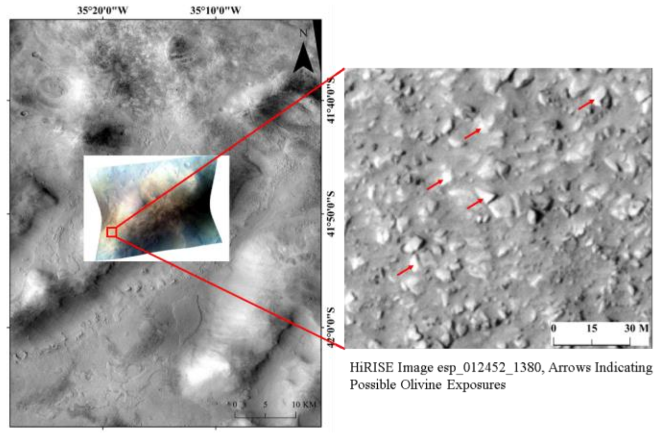

Figure 4 Processed CRISM image CRISM (ID:frt00011b6e_07_if163l_trr3 (R:2.592 G:1.5066 B:1.0800) overlain on CTX (b07_012452_1379). A close-up view of the marked feature in HiRISE image indicates resistant material (indurated sediments) embedded within less resistant matrix.

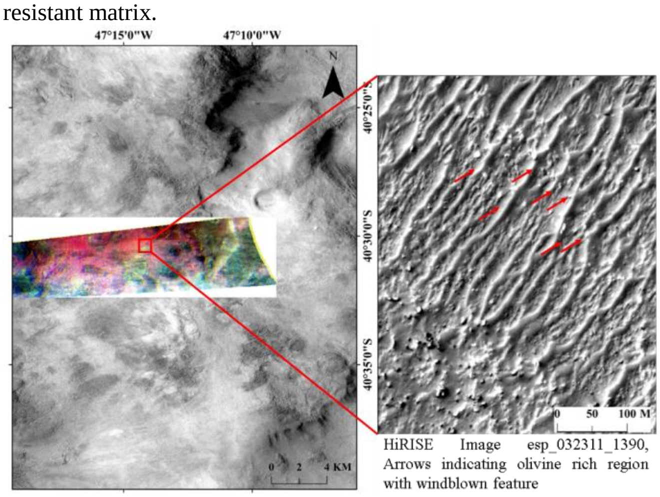

Figure 5 Processed CRISM image (ID:frs00029df1_01_if170l_trr3 (R:2.5031 G:1.3358 B:0.7749) overlain on CTX (J07_047357_1393). A close-up view of the marked feature in HiRISE indicates the exposures along sinuous ridges.

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References:

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