

MINERALOGICAL CHARACTERIZATION OF JUVENTAE CHASMA, MARS: EVIDENCES FROM MRO-CRISM

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ABSTRACT:

Juventae Chasma is a long depression associated with Valles Marineris and this study discusses the spectral observation made after analysing the Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) Full Resolution targeted (FRT) Images in the wavelength region of 1000-2600 nm. Observations reveal the presence of hydrous sulphates, pyroxenes (mafic minerals) and silica rich minerals, more likely opaline silica or glass. Hydrous mineral identified shows the absorption bands, which are more consistent with gypsum. Absorption bands at 2300-2350 nm, and 2500-2550 nm, which are characteristics of carbonates, have been also identified in the region. Presence of this mineral assemblage, confirmed by the observed spectral signatures ranging from volcanic to sedimentary origin, implies a relatively geologically active area, and a significant region in terms of aqueous activity.

1. INTRODUCTION

Juventae Chasma is a box canyon and located north of Valles Marineris. Generally, it is considered as a part of Valles Marineris system, but is separated from the main channel by 500 km. Deposits of Juventae Chasma has been studied by using Mars Global Surveyor (MGS), Mars Orbiter Camera (MOC) and Mars Odyssey Thermal Emission Imaging System (THEMIS) data, Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) (Chapman et al., 2003; Catling et al., 2006; Bishop et al., 2009). The surface of Juventae Chasma has been marked with the presence of mounds and plateau, towards the outflow of Maja Vallis (Chapman et al., 2003; Catling et al., 2006). Mineralogy of Juventae Chasma has been identified and marked with the presence of gypsum identified in horizontal layers nearly hundred meters in thickness each (Gendrin et al., 2005). Kieserite is found in the deposit, surrounding the gypsum deposits and is associated with other rough material at lower elevation (Gendrin et al., 2005). Later, the identified mineralogy shows the presence of sulphates on light toned layers, mafic minerals at bedrock and hydrated silica and ferric sulphate on plateau (Bishop et al., 2009, 2007a; Milliken et al., 2008). Juventae Chasma is 3 km long depression and likely to be formed due to stresses related to Tharsis rise during the late Noacian to early Hesperian period (Lucchitta et al., 1992; Chapman et al., 2003).

Various processes have been assigned to define the deposits in the region, which vary from volcanic (Chapman et al., 2003) to lacustrine or airfall deposits (Catling et al., 2006). Here we present CRISM data results from the mounds, basin floor and wall rock of Juventae Chasma, to get insights into the genesis of the minerals and inferences towards the palaeo-environmental conditions of the region, as it is always considered as one of the potential region to study the aqueous past of Mars. This study shows the identification of carbonates in the region, which will add and improve the model for the generation of the specific mineral assemblage.

2. METHODOLOGY

CRISM acquires images in high-resolution targeted mode using two detectors: a VNIR detector in the spectral range 360–1050 nm and an IR detector covering 1000-3900 nm (Murchie et al., 2007, 2009). Selected CRISM- Full Resolution Targeted (FRT) has been processed using the steps defined by the team over the first Mars year (Murchie et al., 2009). Firstly, the CRISM data was converted to I/F by subtracting the instrument background, dividing by processed measurements of the internal calibration standard, and dividing by solar irradiance (Bishop et al., 2009). Then, images are processed using a cleaning algorithm to remove noise and large spikes within the data because of instrument effects [Parente, 2008]. Band math calculations have been performed to create a set of spectral parameters that distinguish specific features associated with mineral types [Pelkey et al., 2007]. Atmospheric correction was performed by a scaled atmospheric transmission spectrum derived from multiple observations over Olympus Mons. To avoid the irregularity in the spectrum profile, instead of pixel by pixel analysis, regions of interest were selected for better identification of spectral signatures. During the stage of processing of the data, the regions of interest with large noise and irregular spectra were avoided.

3. RESULTS AND DISCUSSIONS

CRISM images from Juventae Chasma (Fig.1) frt00017ae0 and frt00005814, used in this study have been taken from the mound and wall rock regions. Spectral signatures have been indicative of the presence of gypsum in the CRISM image frt00017ae0 (Fig 2a & b). Main absorption bands identified are triplet absorption between 1440-1540 nm, absorptions at 1900 nm, and small absorption at 2250 nm, all due to combinations and overtones of H₂O vibrations and librations (Hunt et al., 1971; Cloutis et al., 2006). One of the most prominent absorption bands is at 2400 nm, which has been assigned to polyhydrated sulphates (Bishop et al., 2007).

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The broad absorption band whose centre lie at around 2200 nm which correspond to the presence of pyroxenes in the region (Fig.3a & b). Carbonates show diagnostic vibrational absorption-bands due to the CO_3^{2-} ion at 2500–2550 nm and 2300–2350 nm (Van Der Meer, 2004). CRISM image frt00005814 also shows weak absorptions at 2300–2350 nm, and 2500–2550 nm, which are diagnostic feature of carbonates. Therefore, the images adjacent to the image frt00005814 could be also processed in further studies for better identification of carbonates, because till now only mono to poly hydrous sulphates, opaline silica and mafic minerals has been reported (Bishop et al., 2009).

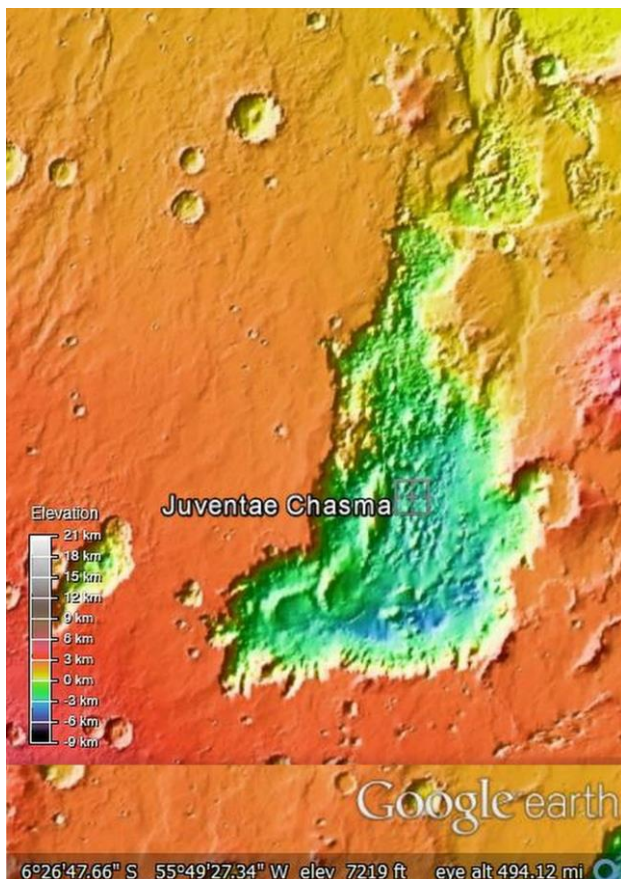


Figure 1. Location and morphological features of Juventae Chasma, Mars; extracted from Google Earth.

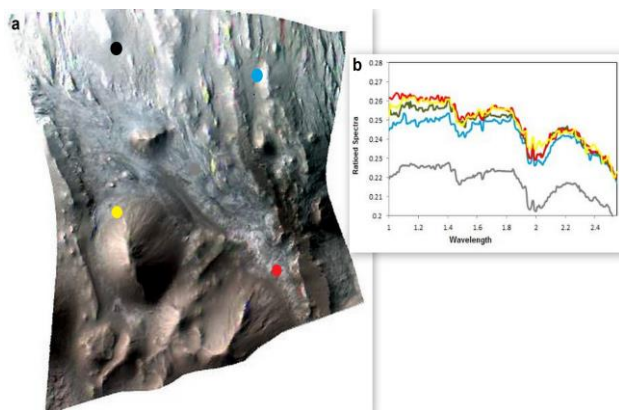


Figure 2. (a) CRISM image frt00017ae0 showing locations of extracted spectra. (b) Spectral signatures derived from the CRISM Image frt00017ae0.

The palaeo-environmental conditions of the region have been developed by many scientists. On the basis of the mineral chemistry and morphological characteristics; Bishop et al., (2009) have suggested acidic aqueous environment in Hesperian time (Bishop et al., 2009). Therefore, identification of other aqueous minerals could add the information to interpret the palaeo-environment of whole sequence of deposit and better model for the formation of identified minerals.

These spectra can work for the spectral library of CRISM data. Earth is also marked with similar canyon features, therefore to better interpret the deposits of Juventae Chasma, one selected site could also be studied in detail to explain the palaeo-environmental conditions of the region.

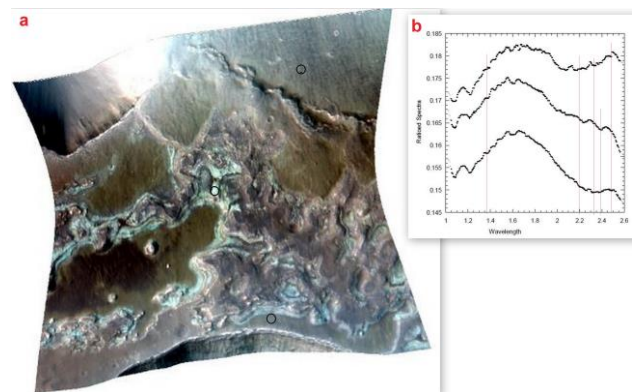


Figure 3. CRISM image frt00005814 showing locations of extracted spectra. (b) Spectral signatures derived from the CRISM Image frt00005814.

4. SUMMARY

The conclusions drawn out of the study are:

- 1) Juventae Chasma is mainly composed of hydrous sulphates and marked by the presence of mafic minerals of pyroxene family,
- 2) Spectral signatures of the region shows the absorptions at 2300–2350 nm, and 2500–2550 nm, which could be linked to the presence of carbonates, and
- 3) Deposits of the region could be studied further to get the actual measures regarding the palaeo-hydration activity in the region and water chemistry in which the deposits have been formed.

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