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Near-Infrared CRISM Investigations of Amazonian Impact Craters on Mars: Comparisons to the Nakhlite Alteration Minerals

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1. Introduction

Recent research has shown how the nakhlite meteorite parent rocks were altered by a hydrothermal brine at ≤200 °C, which may have been a result of an Amazonian-aged impact [1]. Impact induced hydrothermal systems in the volatile-bearing crust of Mars have the potential to last for up to ~10 Myr [2], resulting in various phyllosilicate alteration phases [3]. Such systems have been associated with complex impact craters ≥7 km diameter [2,3].

Using CRISM onboard Mars Reconnaissance Orbiter (MRO), the mineralogy of Amazonian-aged complex impact craters is being characterised to identify the type of crater the nakhlite alteration minerals – smectite, serpentine and siderite (Fe carbonate) – were derived from [1,4-6]. Here we present results from spectral analysis of a crater located in the Amazonis Planitia region of Mars.

2. CRISM

CRISM on MRO is a visible-near infrared and infrared spectrometer that is capable of acquiring 15 – 19 m/pixel resolution images from 362 nm to 3920 nm over 544 channels at 6.55 nm/channel, of a targeted region [7]. Generally CRISM images the surface of Mars at 100 – 200 m/pixel, over the full wavelength range specified above [7].

Using the Java Mission-planning and Analysis for Remote Sensing (JMARS) application developed by the Mars Space Flight Facility at Arizona State University [8], Amazonian-aged complex impact craters ≥7 km in diameter are being identified and the appropriate CRISM files acquired for mineral characterisation.

3. Analysis Techniques

The CRISM spectral data was processed to remove all instrumental effects and to calibrate scene images to scene radiance, from which I/F data is calculated [9].

The CRISM Analysis Toolkit (CAT) extension to ENVI was used for processing the CRISM I/F data. The photometric and atmospheric effects were corrected by division of the cosine of the solar incidence angle and by scaling the atmospheric transmission of CO_2 based on CRISM observations across Olympus Mons. The CIRRUS CRISM clean tool was then used, where appropriate, to reduce destriping and despiking artifacts in the I/F images. Summary products were then used to identify regions of interest, resulting in spectral ratios that are then compared to reference library spectra for mineral identification [9,10]. Principal component analysis and minimum noise fraction transformations will be incorporated in future, where appropriate.

4. Results

One of the craters that met the criteria was identified in the grid square 20° to 30°N, 200° to 210°E. The crater has high resolution CRISM coverage (15 – 19 m/pixel). Figure 1 shows the regions of interest used for the impact crater of ~25 km diameter at 28.7 °N, 207.0 °E. The resultant spectral plots are compared to reference spectral library plots for mineral identification in figure 2.

The ~1.9 µm absorption observed in figure 2 is indicative of H_2O and is common in observations of smectites [11]. The ~2.2 µm absorption is known to be an OH absorption exhibited by Al-rich phyllosilicates [11,12]. OH absorption bands exhibited by Fe^{3+}-rich, Mg-rich and Fe^{2+}-rich phyllosilicates are found in the regions 2.29 – 2.31 µm, 2.33 – 2.34 µm and 2.35 – 2.37 µm, respectively [12].

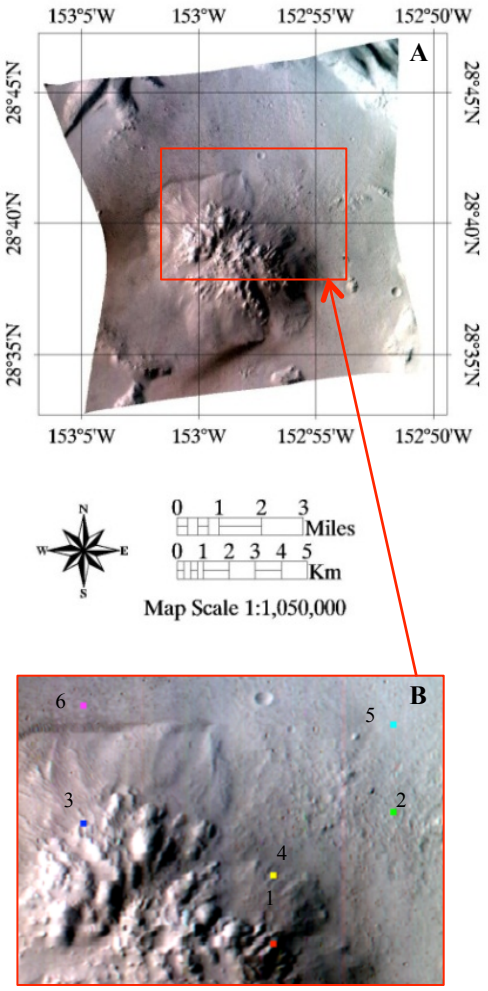

Figure 1: CRISM image frt0000b848 of impact crater located 28.7°N, 207.0°E (153.0°W). A: Full map projected image of the impact crater. B: Pre-map projected cropped image of impact crater showing the locations of three regions of interest and their reference regions of interest each cover a 5x5 pixel area.

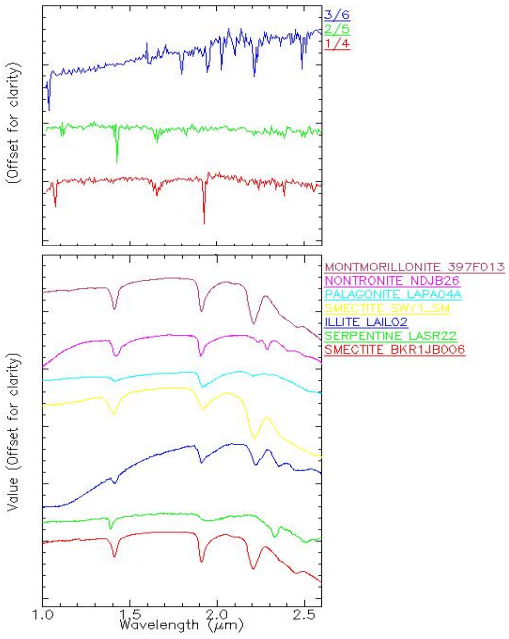

Figure 2: Resultant spectral ratio plots from the regions of interest highlighted in figure 1 compared to CRISM spectral library plots suggested by the ENVI Spectral Feature Fit procedure.

5. Summary and Conclusions

CRISM spectral absorption bands show evidence for smectite and serpentine – two of the nakhlite alteration minerals [1,4-6] – in the complex impact crater located 28.7°N, 207.0°E. This shows the potential for identifying hydrothermal systems in young impact craters on Mars, in addition to those previously characterised from the Noachian [2,3].

References

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