

MAPPING CARBONATES USING CRISM HYPERSPECTRAL DATA. S. Dhoundiyal^{*1}, D. Paul¹, M. Aranha¹, A. Porwal¹, G. Thangjam², ¹Indian Institute of Technology Bombay, India ²National Institute of Science Education and Research, NISER, HBNI, Bhubaneswar, India; *sdhoundiyal@iitb.ac.in

Introduction: Climate models suggest that CO₂ surface pressure of at least 1 atm is necessary to sustain the warm-and-wet conditions characteristic of Noachian Mars under a faint young Sun [1,2]. At present, however, Mars has a CO₂ surface pressure of only 6 mb [3]. The Noachian climatic regime also provided the conditions necessary to form earth-like widespread carbonate deposits. However, widespread carbonate deposits have not been found on the Martian surface. This raises the question: what happened to the CO₂ - was it lost to space, or buried in the form of widespread carbonate deposits? Answering this question requires a robust method for mapping carbonates from orbital remote sensing data.

The most widely used workflow for mapping carbonates from CRISM hyperspectral data consists of three steps: (1) calculate summary spectral parameters and combine them into RGB composites (2) identify promising pixels from the composite images (3) manually investigate the spectra of these promising pixels for absorption features characteristic of carbonates [4-7].

The spectral parameters used in this workflow have some limitations [8]. They are susceptible to noise and may be affected by the shifts in the band centres that would occur due to replacements of the metal ions by the other ions of similar ionic radii and charges. Our experiments indicate that they may return false positives for other minerals such as phyllosilicates, zeolites and pyroxenes, which have absorption features in the same spectral range.

In this paper, we present a novel method to detect carbonates from CRISM hyperspectral data that addresses these limitations.

Proposed algorithm: The proposed algorithm consists of two steps : (1) apply an improved geometric approach to continuum removal for identifying the ~2.3 and ~2.5 μm C-O absorption features (2) use the inter-band gap between the above absorption features to identify carbonates.

Improved Geometric Hull Removal. The algorithm comprises the following two steps: (1) an initial hull is generated after smoothing the input spectrum, (2) this initial hull is iteratively improved till subsequent iterations result in no changes. A broad overview of this method is shown in Figure 1.

Carbonate Identification. Spectral parameters for each absorption feature are calculated. If the ~2.3 and ~2.5 μm absorption features are adjacent and their

band centres & inter-band-gap lie in a prescribed range, the spectrum is marked a carbonate. Figure 2 summarises these steps in a flowchart.

Validation: The proposed method was validated using the CRISM spectral library and the CIRSM MICA type spectra spectral library[9]. Mislabelled samples were removed, and the spectra were resampled to CRISM wavelengths before processing. The results indicate that our method provides improved sensitivity and specificity, as well as higher overall accuracy, compared to the established spectral parameters (Table 1).

TABLE 1: Performance metrics for established spectral parameters and the proposed method

Method	Sensitivity	Specificity	Overall Acc.
Established parameters[8]	0.84	0.77	0.78
Our method	0.86	0.99	0.98

Results and Discussion: Our method was used to process CRISM images from the MICA library [10]. Results from our method and the established spectral parameters for FRT00003E12 are shown in Figure 3.

The established parameters misclassified a number of pixels, most of which were phyllosilicates, as carbonates (Figure 3(c)). Our method does a better job at discriminating phyllosilicates from carbonates, which leads to fewer false positives (Figure 3(a)). However, our method mislabels carbonate pixels on the edges of a deposit as non-carbonates. These limitations are a result of the noise reduction strategy used in our implementation, wherein any detections less than three pixels in size are removed. Currently, we are working on adding an additional step to identify spectrally similar units from the image into our processing pipeline, to address these limitations.

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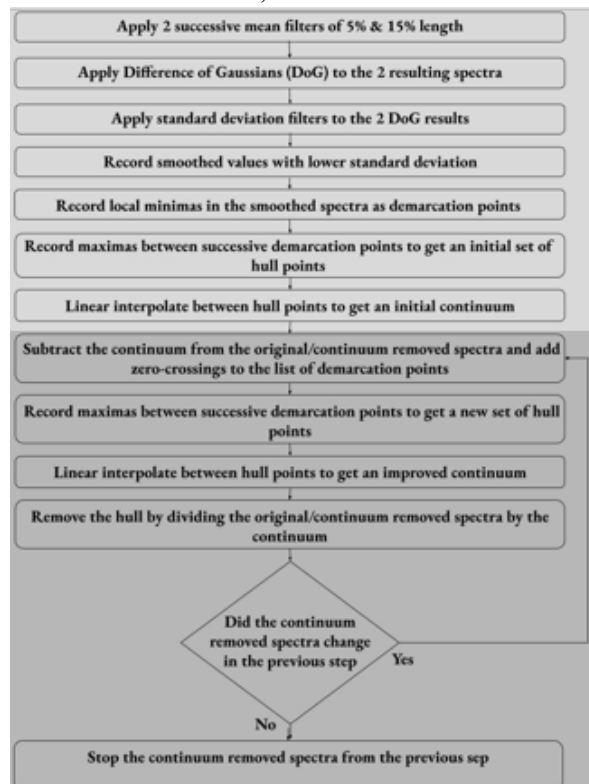


Figure 1. Overview of the proposed continuum removal method with steps for estimating the initial hull (light grey) and iterative improvements (dark grey) highlighted separately.

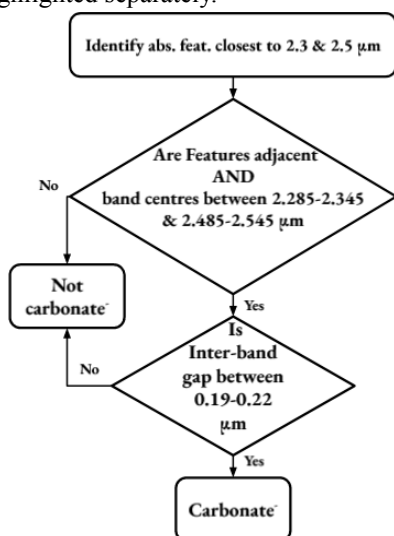
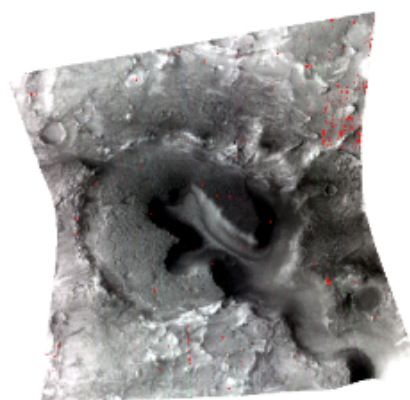
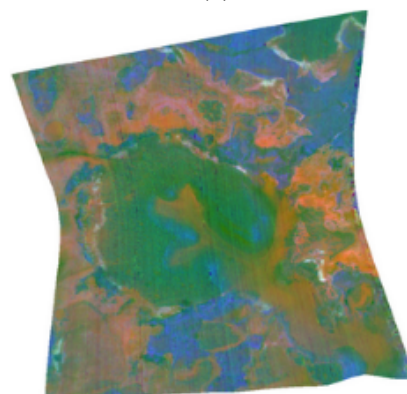


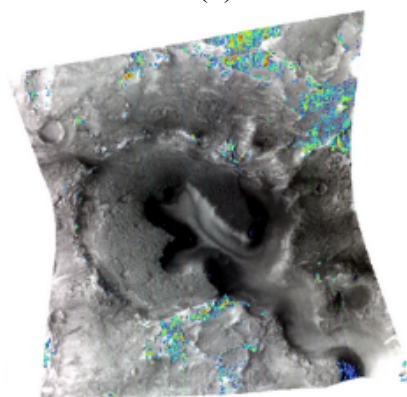
Figure 2: Overview of workflow for classifying spectra as 'Carbonate' or 'Not Carbonate'



(a)



(b)



(c)

Fig 3: (a) Carbonates (red) detected using the proposed method (b) RGB composite (OLINDEX2, MIN2295_2480, MIN2345_2537) with carbonates appearing white (c) Carbonates detected using the established parameters[8] for FRT0003e12