NEW POSSIBLE CRISM ARTIFACT AT 2.1 MICROMETERS AND IMPLICATIONS FOR ORBITAL MINERAL DETECTIONS. E. K. Leask[1], B. L. Ehlmann[1, 2], M. Dundar[3], S. Murchie[4], F. Seelos[4], [1] Division of Geological and Planetary Sciences, California Institute of Technology, MC 100-23, Pasadena, CA, 91125. (Email:eleask@caltech.edu), [2] Jet Propulsion Laboratory, Pasadena, CA, [3]Indiana University-Purdue University, Indianapolis, IN, [4]Applied Physics Laboratory, Laurel, MD.

Introduction: CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) data at visible to shortwave infrared wavelengths (0.4-3.9 µm) have greatly enhanced our understanding of the surface mineralogy of Mars, finding previously undiscovered mineral phases *in situ* and allowing interpretation of mineral occurrences within their topographic context [1]. However, there are several known artifacts in the data set that must be considered to avoid spurious interpretations; a broad spike caused by a filter boundary at 1.65 µm, and a “sawtooth” pattern at ~ 2 µm, caused by imperfect atmospheric correction [2-3]. We have identified another likely systemic artifact in version 3 I/F data at ~2.1 µm, which occurs in scattered locations within most of the >150 CRISM scenes investigated to date (e.g., Fig. 1). The newly recognized artifact resembles a broad absorption due to a mineral phase (spanning ~20+ spectral channels; Fig. 1C) and sometimes co-occurs with a similar feature at 1.9 µm. This may affect identification of hydrated phases (at 1.9µm) as well as minerals such as perchlorates, kieserite, and serpentines, all of which have absorptions at 2.1µm. The 2.1µm feature is found in I/F images in single and few-pixel clusters, typically following topographic edges or in rough terrain. A possible cause is a response lag by some detector elements when there is a strong change in brightness between measurement of successive lines of an image. However, the artifact is not directly correlated with brightness change. We are conducting tests to determine if it is modified by filtering performed when radiance is converted to I/F [4]. For any applications or algorithms that rely on few-pixel or non-contiguous regions, it will be important to keep this possible artifact in mind. Mineral detections based on features near 2.1 µm should be corroborated in radiance data as well as I/F.

Methods: *Rare-pixel detection algorithm.* This feature was first discovered with an algorithm optimized by Dundar et al. [5] to automate detection of rare minerals in CRISM images. Further investigation showed that the pattern remained regardless of atmospheric correction type or denominator used for ratioing, in >150 I/F images. However, the ‘absorption’ is unusual in its geographic distribution (scattered throughout image, although tending to follow ridges/knobs) and spectral characteristics, shifting in band center from 2.10-2.16 µm and without strong correlations with other mineral absorptions or absorption positions. Sometimes it co-occurs with a 1.9µm absorption-like feature similar in strength (e.g. Fig 1C), but not always.

Despiking of radiance data. We examined radiance files rather than I/F to see if the absorption remained and found a correlation between pixels selected by the mineral detection algorithm and those with strong spikes, likely due to a lag in detector response to brightness change (Fig. 1C). Radiance data were ratioed using a

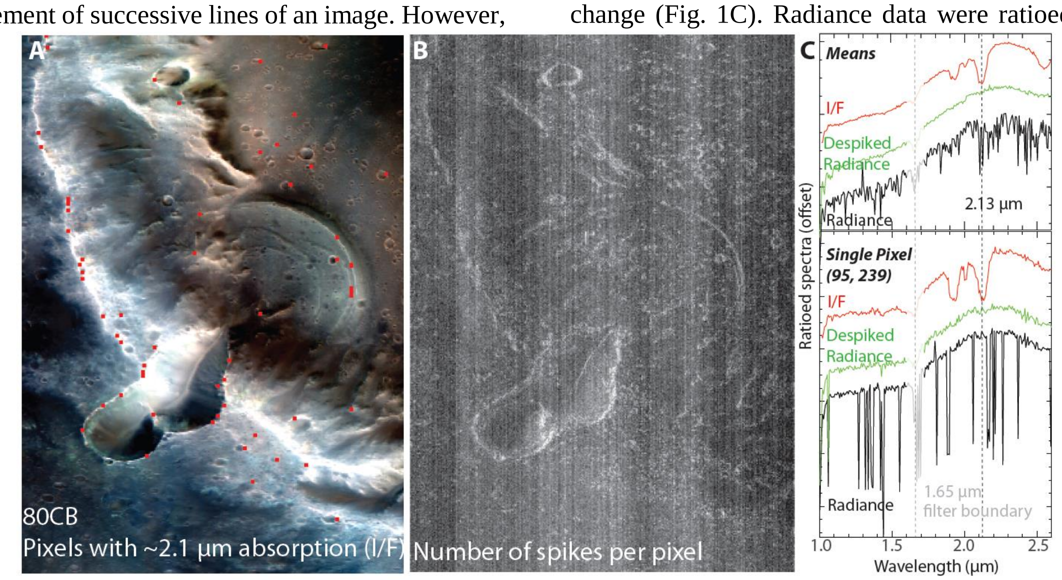

Figure 1: CRISM image (80CB) showing distribution of 2.1µm absorption vs. spikes in data, and example spectra. A) Red pixels (3x actual size) show strongest automated detections of the 2.1µm phase in ratioed, atmospherically corrected I/F data. B) Number of spikes per pixel (sum over 1-4µm) in ratioed radiance data image. C) Comparing ratioed, atmospherically corrected I/F (red), ratioed radiance (black), and ratioed, despiked radiance (green) for the mean of all red pixels in A and a single-pixel example (lower panel).

simple column average. They were also despiked using a two-step median filtering process and then ratioed. Our despiking procedure was designed to account for several spikes in the same wavelength region, while preserving real mineral absorptions. It was tested using several scenes with spiky data over areas well-established to have vibrational absorptions from hydrated minerals. We calculated the sum of the distance between adjacent elements in a 10-channel window. If this number exceeded a threshold, those values identified as spikes would be replaced with the values from a wide (30 channel) median filter, for the spikiest parts of spectra only. A narrow (4 channel) median pass filter was then applied to handle single spikes while keeping real absorptions; this value was used to replace spikes. Only values outside a threshold (here, more than 2% different than the narrow median filter) were replaced, in order to maintain data integrity.

Ratioed I/F data were divided by ratioed, despiked radiance data to examine differences in the spectra caused by processing method. We examined images from across Mars at sites of geologic significance where the clearest examples of the 2.1 μm 'absorption' occur. For a scene lacking spectral contrast as a control, we also examined images from the 2007 global dust storm.

Results: *Spatial patterns.* The suspect 2.1 μm feature in atmospherically corrected, ratioed I/F data tend to follow topographic edges, or are otherwise found in rough terrain (Fig. 1A). Though it is not a 1:1 relation, spikes are also concentrated in these areas (Fig. 1B), suggesting that this type of noise may be responsible for the artifact. Low-contrast mages from the 2007 global dust storm exhibit very few spiked spectra, and are among the few images investigated that have no pixels with this spectral signature at 2.1 μm

Examination of radiance data: Most 'absorptions' in the 2.1 μm region in pixels selected by our algorithm are less obvious in ratioed radiance data and disappear in the despiked data (Fig. 1C, lower panel). A small fraction (generally <10%) still have an absorption in the 2.1μm range after processing, although it tends to be at longer wavelengths (typically 2.16 μm rather than 2.12 μm). We are currently investigating whether these remaining 'absorptions' are consistent with a real mineral phase, and continuing to evaluate unintended effects of the despiking algorithm.

Spectral patterns: Spikes are found at all wavelengths, but are more prevalent at 1.65 μm (a detector filter boundary) and at 2.0 μm (an atmospheric CO_2 absorption; Fig. 2A, B) with a slight uptick in the number of spikes at wavelengths >2.4 μm. They do not occur preferentially at either 1.9 or 2.1μm. The mean ratio of the ratioed, atm.-corrected I/F and ratioed despiked radiance is ~1, as expected. Deviation at ~2 μm is due to the incompletely-corrected CO_2 triplet. In 9 of 18 images, the I/F and radiance data differ most at ~2.1 μm (sometimes also at 1.9 μm, e.g. Fig. 2B). Typically, the broad 'absorptions' at 2.1 μm in I/F data occur when there are many spikes in that wavelength region; in other cases a feature near 2.1 μm occurs without a cluster of spikes. We are testing whether the strong atmospheric CO_2 triplet absorption at 2.0 μm could interfere with the filtering algorithm at the edges of the absorption, generating authentic-looking absorptions at 1.9 and 2.1 μm from spikes in the ratioed radiance dataset (e.g. Fig. 1C).

Conclusions: Few- or single-pixel detections of mineral phases in CRISM I/F data (including those with pixels scattered throughout an image or many images) should be corroborated using unfiltered radiance data, especially if conclusions are drawn from apparent absorptions near 1.9 and 2.1μm. Future work will investigate prior mineral detections and consider changes in the despiking algorithm employed in the radiance to I/F processing.

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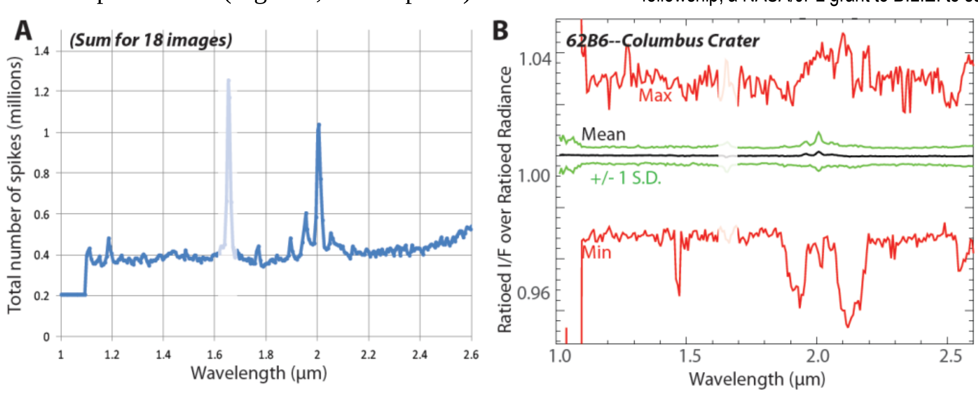

Figure 2: A) The total number of spikes at each wavelength (summing all pixels from 18 ratioed radiance images, e.g. Fig 1B). B) Ratioed, atmospherically-corrected I/F divided by ratioed radiance (despiked) for 62B6. The mean is close to 1, but largest differences between the two processing approaches are at 1.9 and 2.1μm.

References:
[1] Murchie, S. et al. (2009) *JGR:Planets, 114, E00D06,*. [2] Murchie, S. et al., (2009), JGR:Planets, 114, E00D07. [3] Wiseman, S. et al. (2016) *Icarus, 269,* 111-121. [4] Murchie, S. et al. (2016) *MRO CRISM Data Product Software Interface Specification, v.1.3.7.4.* [5] Dundar, M. & B.L. Ehlmann, (2016) *IEEE* WHISPERS, 10.1109.