Quantitative Mineral Abundances in Gale Crater Using THEMIS

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1. Motivation and Background

This study attempts to derive quantitative mineral abundances from the central mound of Gale Crater using thermal infrared (TIR) datasets. The mound has been studied using datasets from the Compact Reconnaissance Imaging System for Mars (CRISM) in the visible and near infrared (VISNIR) [1, 2]. However, many factors make it difficult to obtain quantitative results at these wavelengths. Such issues are simplified at TIR wavelengths where surfaces are assumed to combine linearly.

Thus far, TIR studies of the central mound have been discouraged because of the low spatial resolution of the Thermal Emission Spectrometer (TES) instrument (3 km x ~ 6 km pixel), the low spectral resolution of the Thermal Emission Imaging System (THEMIS) (9 spectral bands) despite the high spatial resolution (100 m/pixel) of the instrument, and the steep elevation change over the height of the mound [3]. Significant slopes can affect the atmospheric correction of spectral data due to varying atmospheric thickness. This study attempts to circumvent these issues by using multiple atmospheric corrections of one THEMIS IR image for spectral analysis, and by using an iterative linear deconvolution method.

2. Methods

¤ Used JMARS [4] to view and/or select CRISM, TES and THEMIS datasets

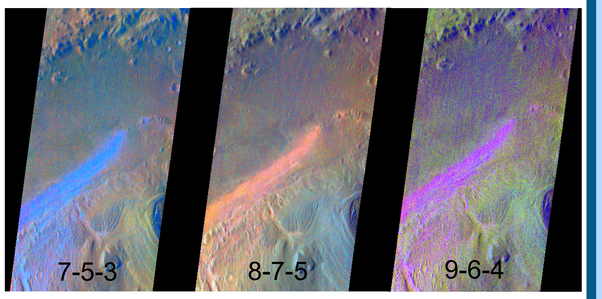
¤ Used TES data from different elevations to produce two versions of an atmospherically corrected THEMIS IR spectral cube I18380009 [5]

¤ Averaged atmospherically corrected spectra from 7x7 pixel areas in the region of interest which correspond to specific compositional units studied by CRISM

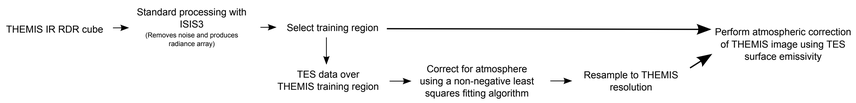
¤ Attempted deconvolution of averaged THEMIS spectra using bands 3 - 9 and a non-negative least squares fitting algorithm

3. THEMIS Data

Decorrelation stretches of THEMIS image I18380009. These stretches highlight band depth (compositional) differences in the image by comparing three bands at once. THEMIS bands range from 6.78 - 14.88 µm with ~ 1 µm steps



4. THEMIS Atmospheric Correction



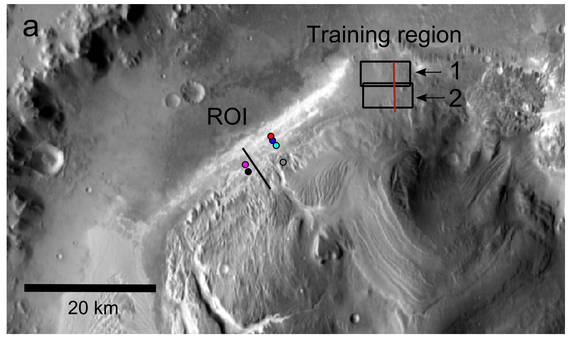
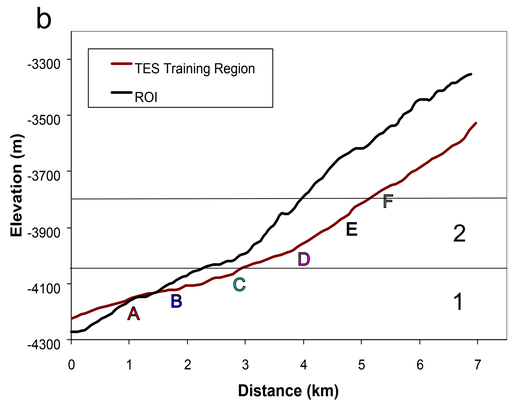


Figure 1. (a) 100 m THEMIS day IR mosaic over Gale Crater. Boxes 1 & 2 in training region correspond to TES data used in atmospheric correction. Colored dots indicate locations of 7x7 pixel areas that produced spectra in Figures 2 and 3, and that correspond to similarly colored letters in (b). Red and black ines show locations of DTM HRSC elevation profiles for the training region and the region of interest (ROI), respectively.

(Figure 1. b) Profiles display similarites in elevation between both regions. I18380009 was atmospherically corrected twice. Spectra from A - C were taken from a cube produced by correction with TES data 1 while D - F were taken from a correction using TES data 2.



5. Results

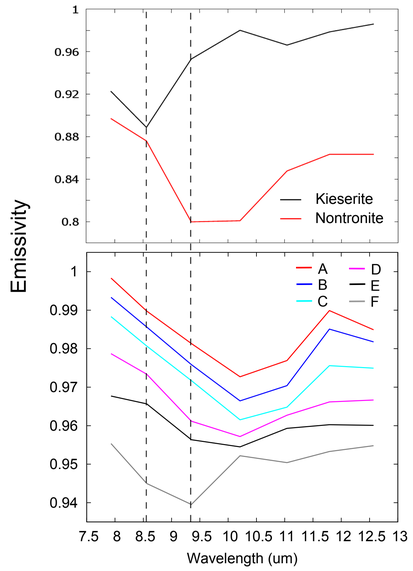
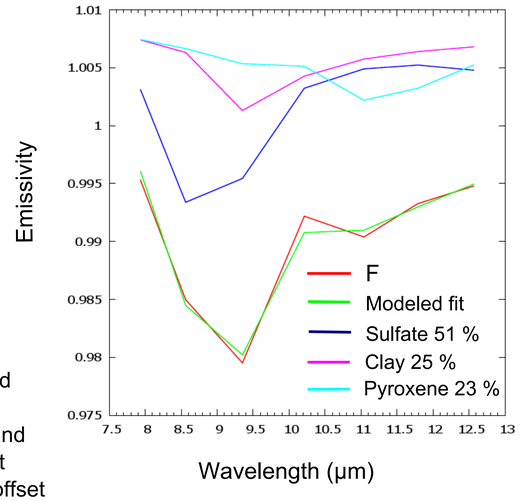


Figure 2 (above). Atmospherically corrected spectra of locations from ROI (bottom) compared to spectra of sulfate (kieserite) and clay (nontronite) (top). Emissivity minima at 8.56 and 9.35 correspond nicely. Spectra offset for clarity.

Figure 3 (below). Example of preliminary deonvolution results for spectrum "F". The modeled fit is not ideal despite the relatively low RMS error = 0.0733545 %, and abundance errors of ± ~ 7 %. Issues that might affect abundances include differences in spectral contrast of spectral library endmembers due to varying particle sizes.



6. Discussion

¤ Elevation-derived atmospheric correction has thus far produced spectral shapes that suggest THEMIS detection of sulfate and phyllosilicate minerals that are in agreement with mineralolgy determined by CRISM

¤ The detection by THEMIS suggests that these minerals are present in abundances greater than the detection limit of THEMIS (~10-15%)

¤ Next steps: deconvolution modeling and mineral abundance maps

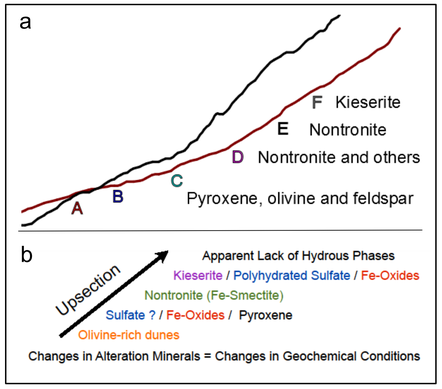


Figure 4 (above). Comparison of results from this study (a) to CRISM (b) [6]

7. References

[1] Milliken, R.E. et al. (2009) LPSC, abstract #1479. [2] Milliken, R.E. et al. (2010) GRL, 37, L04201. [3] Rogers, A.D. and Bandfield, J.L. (2009) Icarus, 203, 437-453. [4] Christensen, P.R. et al. (2009) http://adsabs.harvard.edu/abs/2009AGUFMIN22A..06C. [5] Bandfield, J.L. et al. (2004) JGR, 109, E10008. [6] Milliken, R.E. (2011) MSL Workshop.

8. Acknowledgements

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