MULTISPECTRAL ANALYSIS METHODS FOR MAPPING AQUEOUS MINERAL DEPOSITS IN PROPOSED PALEOLAKE BASINS ON MARS USING THEMIS DATA. K. R. Stockstill[1], J. E. Moersch[1], H. Y. McSween, Jr.[1], P. Christensen[2], [1]Dept. Earth and Planet. Sci., Univ. Tennessee, 306 Earth and Planet. Sci. Bldg., Knoxville, TN 37996, kstockst@utk.edu, [2]Dept. Geol. Sci., Arizona State Univ., Tempe, AZ 85287.

Introduction: Several geomorphic studies have proposed the existence of paleolake basins on Mars [*e.g.*, 1,2]. A list of 179 proposed paleolake basins in impact craters was compiled with corresponding geomorphic evidence for each basin [1]. Among the geomorphic evidence, it was noted that some basins display alternating bands of light and dark albedo materials conformal with basin margins. It has been suggested (*ibid.*) that the bright materials may be evaporite deposits, but spectral studies of these areas have not confirmed this hypothesis [3,4,5].

Recently, we conducted a TES study to search for small (~5 km-scale) exposures of evaporite minerals within the 80 largest putative paleolake basins from the list presented in [1]. Seven basins displayed one or more surface spectral units distinct from their surroundings. Averaged TES spectra from regions of interest (ROI) were extracted and examined to see what spectral features distinguish these units from each other. Linear deconvolution of the mean ROI spectra was used to search for carbonates (*ibid*). In addition, new spectral indices, sensitive to the carbonate absorption features near 890 cm^{-1} and 360 cm^{-1} and their relative band depths, were developed to search for carbonates present in abundances >12-53% (depending on the specific variety). The deconvolution routine never used evaporite minerals in credible amounts (i.e., not > 10-15%) and the spectral indices method did not detect carbonates in any TES ROI mean spectra [5].

THEMIS vs. TES: The Thermal Emission Imaging System (THEMIS) aboard the Odyssey spacecraft is acquiring thermal infrared images at 100 m/pixel resolution in nine spectral bands. Due to its higher spatial resolution, THEMIS is best considered as a spectral unit mapper whereas, due to its higher spectral resolution, TES would typically be better at mineral identification. Therefore, using data from THEMIS to produce spectral unit maps will provide a way to search for potential aqueous mineral deposits of a smaller scale than the 3x5 km TES footprint. If potential deposits are detected, a TES spectrum of the same area could be examined for subtle spectral features. Similar TES/THEMIS combinations have been used to map and then compositionally identify outcrops of olivine in Ganges Chasma [6].

Methods: A list of THEMIS daytime IR image cubes covering the proposed paleolake basins has been compiled and filtered for local solar time (LST). Only THEMIS image cubes obtained before 1600 LST will be used due to decreasing signal-to-noise for later LSTs. Each THEMIS image cube meeting this criterion is geographically projected using software written at Arizona State Univeristy.

A radiance offset correction must be applied to these image cubes because of an additive contribution from downwelling radiance from the atmosphere, as well as additive instrument calibration error. Following the method described in [9], a geologic feature that can be reasonably assumed to have uniform emissivity spectra and a relatively large range of temperatures is identified and defined as an ROI. Because of the radiance offset problem, uncorrected emissivity spectra taken from within the chosen ROI are not generally uniform. A minimization routine calculates the radiance offsets for each band that are necessary to produce uniform emissivity spectra within the ROI. These derived offsets are then applied to the full radiance image cube, which produces a corrected radiance image cube, a corrected brightness temperature image (e.g., Figure 2) and an emissivity image cube that still contains atmospheric absorptions.

Next, an area in the scene thought to be covered in dust (often known from the TES study or from THEMIS night IR images) is identified and defined as an ROI. The mean spectrum from this ROI is forced to match a TES-derived surface dust spectrum [8] using a multiplicative gain factor in each band. These gain factors represent absorption from the atmosphere. The gain factors are then applied to the full scene, producing a surface emissivity image cube.

Finally, a PCA is applied to the corrected emissivity image cube to enhance surface spectral variations. Spectral units are identified within the PCA image (e.g., Figure 3). The high spatial resolution of THEMIS data may allow identification of spatially-confined deposits of aqueous minerals. We then collect spectra from the TES pixel or pixels corresponding to the outcrop/deposit and perform linear deconvolution and apply the carbonate indices to this spectrum.

Results and discussion: As an example of our technique, the initial results for Gale Crater (-5.5, 137.8E) will be discussed. Figure 1 displays an uncorrected brightness temperature mosaic containing all THEMIS stamps acquired before 1600 LMT. The two images within Gale Crater acquired at the earliest LMT are outlined in Figure 1 in red (1514 LMT) and aqua

(1527 LMT). These two images were processed for both radiance offset and atmospheric removal steps. The corrected brightness temperature images are displayed in Figure 2. Both images display a bright (warm) material on the floor surrounding the central mound.

In addition, the results from PCA analysis of the corrected surface emissivity data are shown in Figure 3. The most distinct surface units are the central mound (in greens) and the crater floor (in pink tones). The latter corresponds well to the bright (warm) material visible in Figure 2. Initial results of linear deconvolution and carbonate indices method on single TES pixel spectra overlapping these surface units do not require carbonates. Work is currently underway to determine the spectral causes of the color variations seen in Figure 3. We are also beginning work on applying the methods described to other proposed lake basins.

References: [1] Cabrol and Grin (2000) *Icarus, 149,* pp. 291-328. [2] Forsythe and Zimbelman (1995) *JGR, 100,* 5553-5563. [3] Ruff et al. (2001) *JGR, 106, 23921-23927*. [4] Stockstill *et al*. (2003), *Mars 6 Conf.*, Abstr. No. 3183. [5] Stockstill *et al.* (2004), *JGR*, *in prep*. [6] Christensen *et al.* (2003), *Science,* 10.1126/science.1080885. [7] Bandfield et al. (2000) *JGR, 105,* 9573-9587. [8] Bandfield and Smith (2003), *Icarus, 161, 47-65*. [9] Bandfield (2003), *Fall AGU*, abstr. P21C-01.

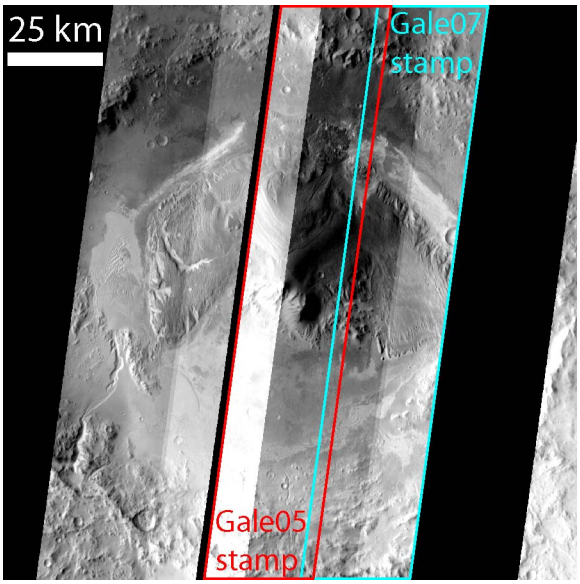

Fig. 1: Uncorrected brightness temperature mosaic of THEMIS images acquired before 1600 LST of Gale Crater. The images used in Figs. 1 and 2 are outlined in red (Gale05) and aqua (Gale07).

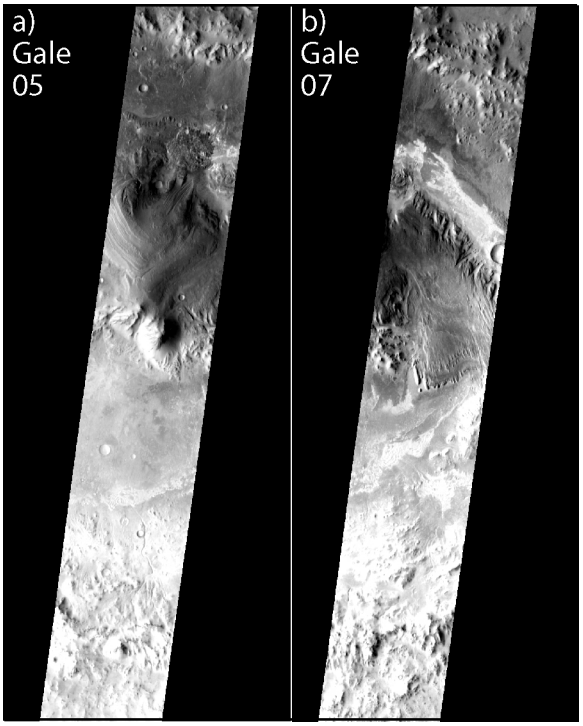

Fig. 2: Corrected brightness temperature images of a) Gale05 cuts through the center of the basin, crossing the central mound. b) Gale07 crosses the eastern floor of the basin.

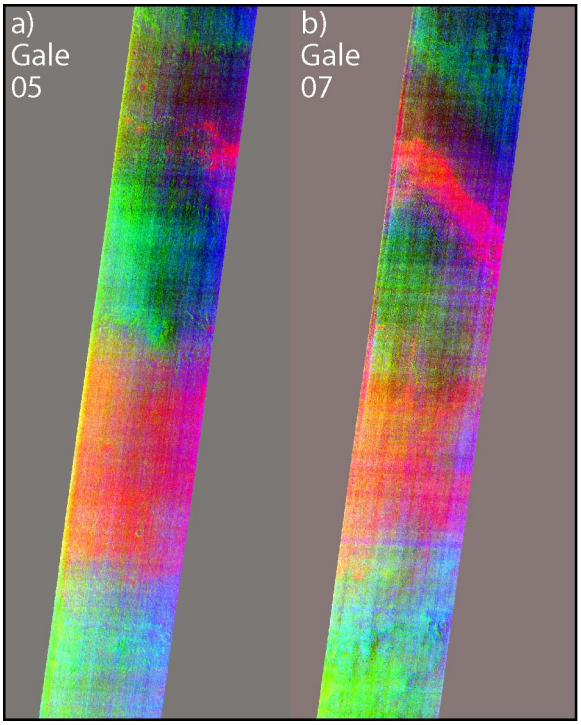

Fig. 3: Three band PCA image of a) Gale05 and b) Gale07. Both images display similar surface units on the floor of Gale Crater. The mound is visible in bright green, while the bright (warm) floor shows up in pink tones.