SEARCH FOR EVAPORITE MINERALS IN FLAUGERGUES BASIN, MARS

J.B. Dalton[1,2], B. Sutter[1,2], M.G. Kramer[3,2], K.R. Stockstill[4], J. Moersch[4], and J.M. Moore[2], [1]SETI Institute, [2]NASA Ames Research Center, [3]California State University, Monterey Bay, [4]University of Tennessee, Knoxville. (dalton@mail.arc.nasa.gov)

Introduction: Studies of Martian surface geomorphology and detection of near-surface water ice by the Mars Odyssey gamma ray spectrometer suggest that Mars may have had a water-rich past. While 2 to 5 wt.% of carbonate has been detected in the Martian dust [1,2], no spectral evidence for significant deposits of carbonates or sulfates has been found to date. Most investigations into Mars aqueous mineralogy have been global in scope with only a few regional studies (e.g., [3]). We are searching for localized deposits in putative lacustrine basins utilizing a basin flow model to identify basins with large drainage areas. Such basins are more likely to accumulate high concentrations of aqueous minerals than deep basins which drain only small regions.

Methodology: We apply a surface water flow model to identify potential paleolakes. Next we evaluate these paleolakes based on Mars Orbiter Laser altimeter (MOLA) shaded relief maps and available Mars Observer Camera (MOC) and Mars Odyssey Thermal Emission Imaging Subsystem (THEMIS) images. We then examine Thermal Emission Spectrometer (TES) data to determine if the basins possess evidence of aqueous mineralogy.

Basin Flow Model A flooding algorithm [4,5] utilizes a 1-km resolution digital elevation model derived from the MOLA data to identify depression features and hydrologic pathways. The model applies a spatially explicit routing scheme to simulate daily discharge dynamics in watersheds to reconstruct stream flow across a land surface. Shallow basins which contain evidence for surface flow activity (stream features, ancient lakebeds) in the image data are prioritized for spectral analysis.

MOC AND THEMIS Imaging Analysis Visible-wavelength MOC and THEMIS IR images are used to identify areas which are not heavily mantled by dust deposits in order to focus observations on areas where the local mineralogy is dominant.

Thermal Emission Spectroscopy Analyses TES emissivity spectra of candidate basins are assembled into a hyperspectral cube that allows visualizing spatial relationships that might be missed if the spectra were examined individually. A Minimum Noise Fraction (MNF) transform is applied to the hyperspectral cube, allowing inter-orbital (i.e. atmospheric) variations to be removed so remaining spectral variation is due to surface spectral units.

Regions of Interest (ROIs) are defined by highlighting areas of possible pooling identified by the basin flow model; selecting spatially-continuous areas of distinct MNF values in the TES hyperspectral cube; and by using visible MOC and IR THEMIS imagery to locate regions of high thermal inertia and low dust cover. TES spectra within each ROI are averaged to produce a mean ROI spectrum. We then model these with a linear combination of Acidalia- and Syrtis-type, two water-ice cloud, two surface dust and a unit emissivity endmember [6].

Spectra that are not well matched by any combination of the above endmembers are modeled using a downhill simplex algorithm [7] and the USGS Tetracorder system [8] with the ASU Thermal Emission Spectral Library to evaluate evidence for aqueous mineralogy.

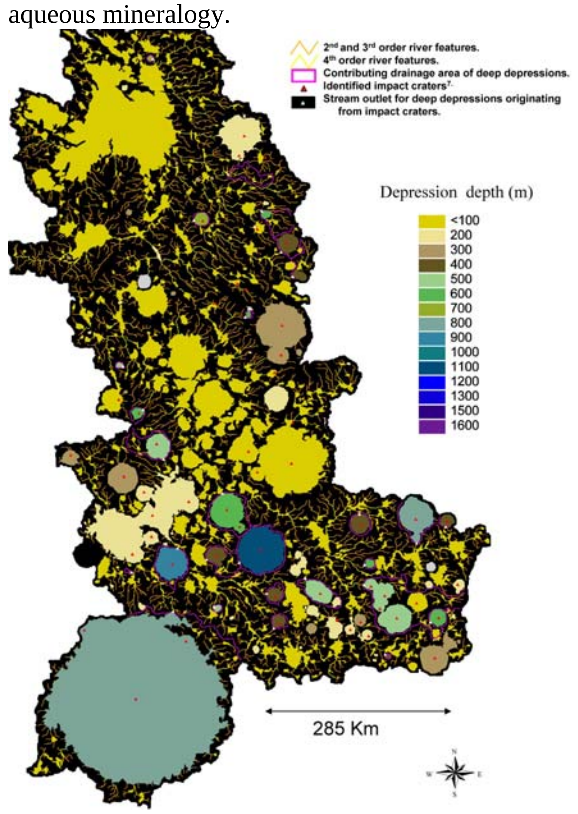

Fig. 1. Basin flow model results for the Flaugergues drainage divide.

Results and Discussion: Simulated surface flow in the Flaugergues drainage divide in the Noachis region of Mars (16.8 S, 340.8 W; [4]) indicates areas of water accumulation (Fig. 1). Putative paleolakes residing in craters (e.g., Gusev Crater, Schiaparelli) have already been examined for evidence of aqueous minerals. However, basin flow models suggest that craters deeper than low-lying basins do not necessarily drain large areas. Raised crater rims often isolate craters from their surroundings. The model has identified areas of water accumulation fed by large geographic areas which could produce enhanced transport of aqueous materials.

MOLA A shaded-relief map constructed from MOLA data was used to assess the geomorphology of putative paleolake basins. Many were found to exhibit smooth features suggestive of a lake bottom.

THEMIS Nighttime thermal infrared imagery was georeferenced to the MOLA base map. Extensive dark regions indicate that the thermal inertia is low in the areas of interest, suggesting that dust may be a problem in the TES analysis. Some bright regions were identified in the THEMIS IR data and recommended for further analysis.

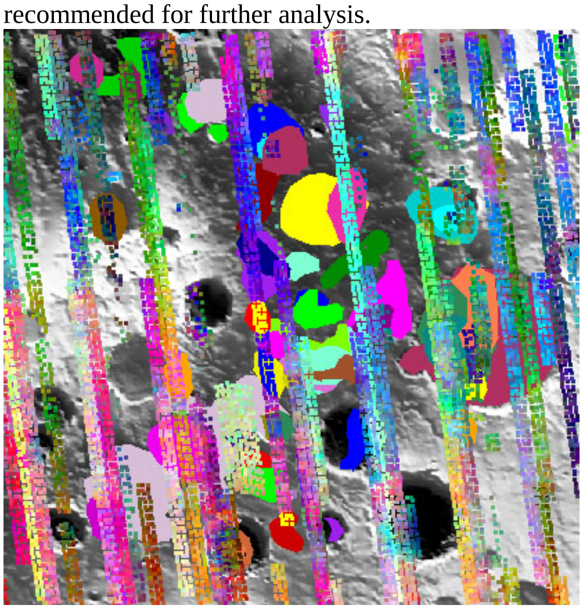

Fig. 2. MNF-transformed TES data for the Flaugergues Basin, over selected ROI basins.

TES Data Processing Spectra of the Flaugergues region were extracted using the Vanilla software with the appropriate selection criteria for near-nadir emission angle, moderate phase angle (<120^o), high daytime surface temperatures, and high quality data. Regions of interest were defined by the outlines of putative paleolake basins from the surface flow model, by contiguous areas of specific variation in the MNF-transformed data, and by bright areas in the nighttime THEMIS imagery. Some regions overlapped; in others, there were no TES pixels available. Only a few small areas belonged to all three sets. Spectra from sixty-three regions have been studied thus far, and of these, eighteen warranted further spectral analysis. ROI #24 (red kidney-shaped basin at bottom center in Fig. 2) exhibits a strong local contrast in the MNF-transformed data and is moderately bright in the night time THEMIS data.

Linear Spectral Modeling Figure 3 demonstrates modeling results for region #24. Basin #24 was modeled using a downhill simplex algorithm which adjusts component abundances in pursuit of a minimum chi-squared value. While abundances may be zero in this formulation, the sum must total unity, and nonphysical values (such as negatives) are not allowed. We used the standard ASU spectral endmembers [6]. The spectrum includes significant signal (>30%) from surface materials. Combinations using only the standard endmembers were not sufficient to match the spectrum. The residual (dotted blue) suggests an additional surface component with absorptions near 900 and 350 cm^{-1}. While this could include either olivines or carbonates (e.g., fayalite, siderite) the detail of Figure 3 is insufficient to claim an identification. Further modeling is underway.

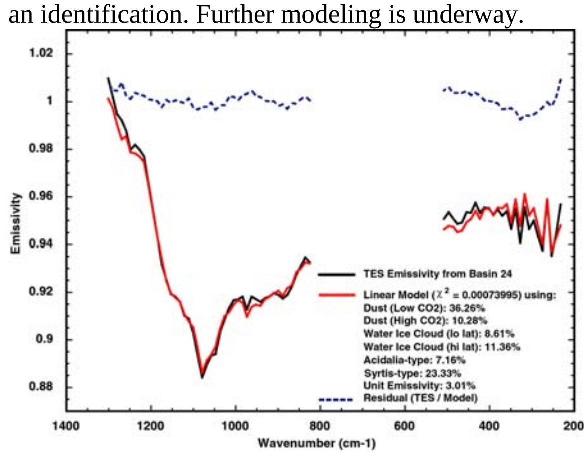

Fig. 3. TES spectral average (black) for region #24 with linear mixture (red) using dust, water ice clouds, and surface endmember (including unity) components. Residual is shown in blue, with no scaling applied.

Conclusion: No conclusive evidence for evaporites in Flaugergues has yet been detected. Initial selection criteria for TES spectra were too restrictive and the amount of spectra made available was limited. We are currently examining additional spectra of the Flaugergues region and conducting further modeling. The results shown here demonstrate that a directed search utilizing a basin flow model has the potential to constrain the presence (or absence) of Martian aqueous minerals.

References: [1] Pollack J.B. *et al.* (1990) *JGR 95*, 14595. [2] Bandfield J. *et al.* (2003) *LPSC XXXIV* 1723. [3] Stockstill K.R. *et al.* (2003) *6th Int'l Mars Conf.*, 3183. [4] Kramer M.G. *et al.*, (2002) *Eos Trans. AGU 84*, 6. [5] Coe, (2000) *J. Climate 13*, 686. [6] Bandfield J. *et al.* (2000) *Science 287*, 1626. [7] Bauer M. *et al.*, (2002) *Icarus 158*, 178. [8] Clark R.N. *et al*. (2003) *JGR 108*, 5131.