SPECTRAL AND GEOMORPHIC EVIDENCE FOR CHEMICAL WEATHERING IN THE ICY PLAINS OF ACIDALIA PLANITIA, MARS. M.D. Kraft[1], A.D. Rogers[2], R.L. Fergason[3], J.R. Michalski[4], and T.G. Sharp[1], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, mdkraft@asu.edu, [2]Department of Geosciences, Stony Brook University, Stony Brook, NY, [3]United States Geological Survey, Flagstaff, AZ, [4]Planetary Science Institute, Tucson, AZ.

Introduction: With discoveries of hydrous mineral suites in Noachian and Hesperian terrains, investigations of weathering on Mars have concentrated on earlier periods of Martian history. It is important to understand how aqueous processes and alteration have changed over time and whether aqueous alteration has persisted into more recent times of the Amazonian Epoch. Because Amazonian surfaces, such as the northern plains, lack hydration features in near-infrared spectra, it has been suggested that the Amazonian was characterized primarily by anhydrous, oxidative weathering [1,2]. NIR hydration features, however, can go undetected under certain conditions, such as when rocks have thin coatings of hydrous silica [3]. The high-silica materials (Surface Type 2, ST2) discovered by the Thermal Emission Spectrometer (TES) [4] occur in the Amazonian northern plains. ST2 surfaces are generally thought to be comprised of altered basaltic materials [5,6]. Thus, ST2 strongly suggests aqueous alteration of silicate minerals. It is important to constrain when the alteration occurred and under what conditions.

Although the northern plains has been mapped as Amazonian [7], ST2 correlates spatially with outflow sediments of the Vastitas Borealis Formation (VBF), and high-silica materials may have formed in large amounts of water related to outflow flooding events of the late Hesperian [5]. ST2 also has spatial correlation to global-scale ice-rich mantles, indicating a possible formation in icy environments related to geologically recent climate fluctuations and Amazonian resurfacing of the northern plains [5]. Thus, the timing, mechanism, and amounts of water involved in alteration are poorly constrained. This study is intended to provide better constraints to this important process that has affected a large area of the planet.

A refinement of ST2 composition using TES spectra found significant spectral differences between ST2 surfaces in northern and southern Acidalia Planitia [8]. This compositional boundary occurs near 40-50° N latitude, which correlates well with several global-scale geomorphic transitions, many of which are directly or potentially related to Amazonian periglacial activity. The possible link between composition and periglacial morphology provides a means to better constrain the timing and process of ST2 formation. This work is a preliminary assessment of the correlation between compositional and geomorphic transitions near 40-50° N using higher resolution datasets.

Methods: We examined the spectral differences in western Acidalia Planitia using Thermal Emission Imaging System (THEMIS) multispectral data to measure the local spectral properties of the surface. For this preliminary study, we selected a single THEMIS observation (I20845002) that spans 42.7-60.6° N latitude (~1060 km), spanning the TES-derived compositional boundary in this region (Fig.1). A decorrelation stretch (DCS) of bands 7-6-5 was used to identify regions of spectral difference that were consistent with the north and south Acidalia spectral shapes [8]. Areas were selected from the DCS image from which to derive surface emissivity spectra that captured the overall spectral variability. The I20845002 observation shared good coverage with Context Imager (CTX) and High Resolution Imaging Science Experiment (HiRISE) data, enabling a photogeologic assessment of geomorphic features. CTX imaging was used to assess broader geomorphic differences in the region, while HiRISE data provided high-resolution information about representative surfaces.

Results and interpretation: We identified a clear boundary between two surface spectral types from the THEMIS observation (Fig 1), and they closely match the TES spectra of north and south Acidalia (Fig.1C). The boundary is diffuse, occurring between 45-49° N, but it is clear that the areas north and south of this boundary are spectrally different from one another. Broad differences were observed across this spectral boundary in CTX images, suggesting morphological variations between north and south. Close-up examination of those surfaces with HiRISE images shows marked differences between surfaces. The area south of the boundary is characterized by rounded hummocks and ridges (Fig 1.E2). The area north of the boundary shows vestiges of hummocks, but it is generally much flatter and covered by small polygons (Fig. 1.E1). It is evident that the north and south areas share a common origin because they both have hummocks of the same size and form; however, these have been subdued in the northern area, where they are overprinted by periglacial polygonally patterned ground. Thus, ground ice has modified the surface morphology in the north. Because of the close spatial association of these geomorphic differences to observed spectral differences, we suggest that periglacial processing also modified the composition of the northern surface materials.

Discussion: While other alteration conditions possibly led to the spectral differences between north and south Acidalia, the close spatial correlation between onset of periglacial features and composition change to the north indicates the involvement of ground ice, supporting previous suggestions that ST2 formed by aqueous weathering in ice-rich soils [3]. Such weathering occurs in periglacially affected Antarctic soils, where silica is mobilized by thin water films, forming silica gels [9]. The ST2 composition of south Acidalia may be a remnant of alteration related to outflow events, which has been modified by the icy weathering we suggest. The north-south transitions examined here seem likely to occur throughout much of the northern plains. While this requires much further study, the implication is that chemical weathering has been widespread over the northern plains and may have persisted over much of the Amazonian.

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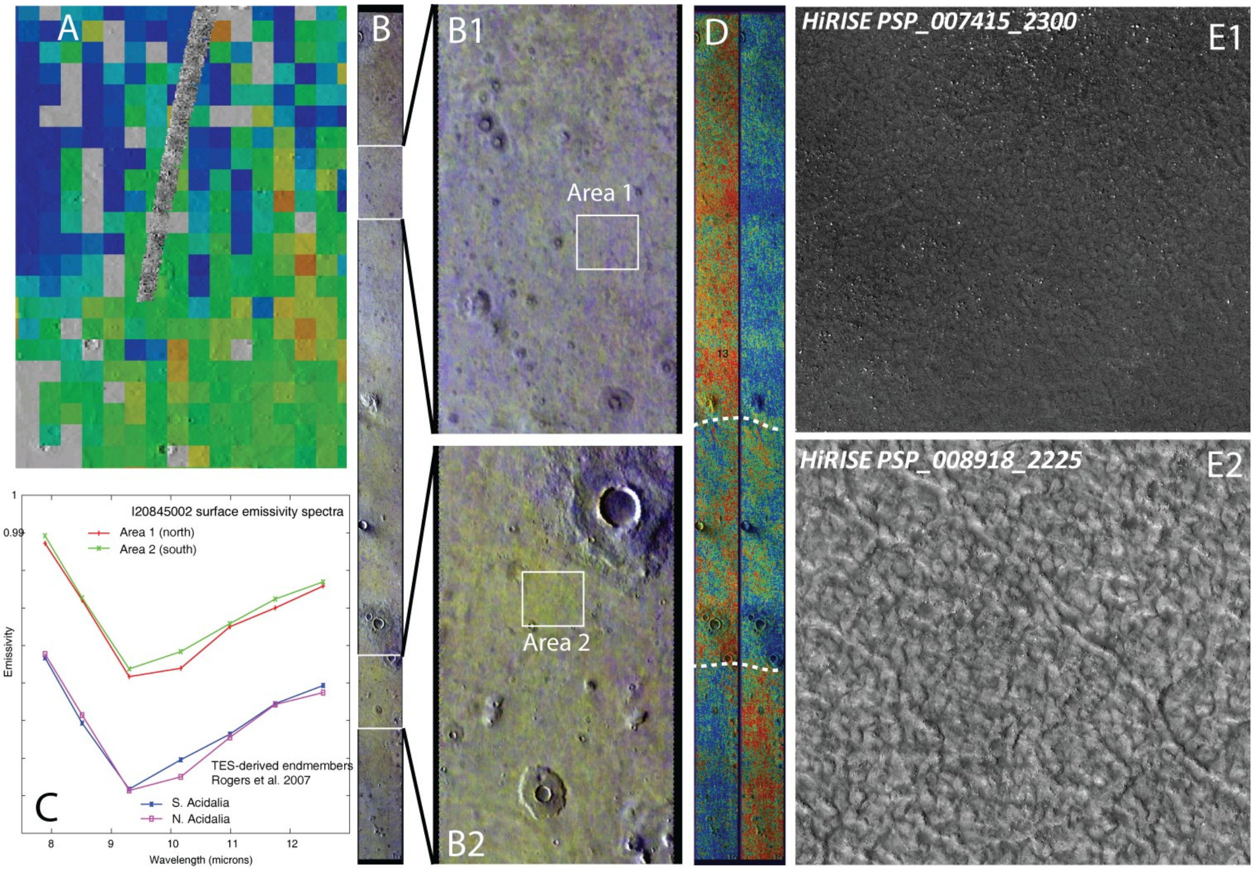

Figure 1. (A) THEMIS radiance image I20845002, overlaid on TES southern Acidalia distribution [8]; (B) THEMIS radiance image I20845002, decorrelation stretched (DCS) using bands 7, 6, 5 displayed as red, green and blue. Increasing green to the south indicates higher emissivity in Band 6 (10 .4 µm). White boxes show locations of (B1) and (B2), within which white boxes indicate areas where average THEMIS surface emissivity spectra were extracted; (C) Average THEMIS surface emissivity spectra from B are compared to TES-derived northern and southern Acidalia endmembers [8]. Both sets of spectra are primarily distinguished by Band 6; (D) THEMIS spectra extracted from the two areas in B were used to model the surface emissivity of the entire image. Spectral unit distributions for the "Area 1" and "Area 2" endmembers are shown on the left and right, respectively, a provides an additional quantitative method for visualizing spectral shape distributions. The dashed lines bracket a "transition zone" where both spectral shapes are used to model the surface. Areas north of this zone are dominated by the northern Acidalia spectral shape, whereas areas to the south are dominated by the southern Acidalia shape; (E) HiRISE images showing high-resolution view from (E1) north and (E2) south of the boundary. Note that the southern image shows numerous ridges and hummocks. In the northern image, those same features are strongly subdued and overprinted by periglacial patterned ground.