JOINT OMEGA-THEMIS INVESTIGATION OF TES TYPE II DEPOSITS AND LOCAL TERRAIN, NILI PATERA, SYTRIS MAJOR, MARS.

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Introduction: Enhanced understanding of the mineralogy of the Martian surface can be achieved through joint analysis of the near-infrared and thermal datasets. Because the physical processes of absorption differ in these wavelength regimes, the joint datasets are complimentary and offer important insights into surface compositions and textures unattainable through independent and comparative analysis. Using an integrated dataset we investigate the central caldera of Syrtis Major, which is an advantageous location because of its mineralogic diversity as well as uniquely strong spectral signatures. We examine the spectral and geomorphologic characteristics of two TES Surface Type II deposits in this region, previously identified in [1], in the context of the local spectral diversity. Surface Type II is a global geologic unit identified within the TES dataset, and contrasting compositional interpretations of this unit imply very different surface evolution processes [2,3,4]. Because many previous investigations utilize the thermal emission dataset only, a detailed joint analysis of high-resolution OMEGA and THEMIS data can contribute important information.

Dataset: At near global coverage, the OMEGA near-infrared imaging spectrometer on Mars Express operates with a 1.2 mrad IFOV and 352 spectral channels between 0.35 μm and 5.2 μm [5]. The spatial resolution varies from 300 meters/pixel at pericenter to 4.8 km/pixel at 4000 km altitude. With global coverage, the THEMIS thermal emission imaging spectrometer observes with nine spectral channels between 6.8 μm and 14.88 μm at ~100 km per pixel [6].

Background: This analysis combines data with the highest spectral resolution in the near-infrared (OMEGA) with the highest spatial resolution in the thermal infrared (THEMIS). Previous studies have taken advantage of the benefits of joint analysis [e.g. 7,8] noting enhanced mineralogic and textural interpretations. Prominent absorptions at VNIR (visible near-infrared) wavelengths are the result of charge transfers and electronic transitions while the TIR (thermal infrared) region is dominated by crystal lattice vibrations. Also, variations in grain size systematically affect spectral contrast and absorption band depth at VNIR and TIR wavelength regimes independently. Thus, a combined OMEGA-THEMIS dataset allows for a rigorous analysis of mineralogy and texture.

Data from the TES instrument indicate the presence of two dominant surface mineralogies [2]. Deconvolutions of Surface Type I, whose type locale exists within the Syrtis Major region, indicate a basaltic composition [2]. Initial interpretations of Type II, typified by spectra in Acadalia Planitia, suggest an andesitic composition [3]. Other proposals for the composition of Type II include weathered basalts [4] or a dominant component of silica-rich glass [9]. Each of these spectral interpretations has significant but contrasting implications about the geologic history and evolution of the Martian surface. Thus it is important to further address this theme with complimentary datasets.

Syrtis Major, a large topographically low shield volcano, is an excellent location to rigorously examine spectral variations including Type I and Type II using a joint OMEGA-THEMIS dataset. [1] studied the TES-THEMIS data for this region and noted four prominent mineralogic and geologic units within Nili Patera, the central caldera of Syrtis Major. These units include an eroded Type I exposure, two Type II deposits, one of which is thought to originate from nearby volcanic cone, and a large dune field. In addition to the variations observed at TIR wavelengths, Nili Patera also offers some of the strongest absorptions and significant spectral diversity at VNIR wavelengths.

Methods: One OMEGA cube (ORB0488_3) and three THEMIS day-time cubes (I08561006, I08149019, I01820006) that image the Nili Patera region of Syrtis Major were atmospherically corrected and assigned geographic coordinates. The correction method of [10] was applied to the OMEGA data and two emissivity calibrations [11,12] were applied THEMIS data for comparison. The individual datasets were spectrally and spatially merged at an intermediate resolution. Statistical analysis of the joint dataset allows for objective characterization of in scene spectral variance. The Modified Gaussian Model (MGM), which deconvolves mafic mineral composition and relative abundance, was applied to averaged OMEGA spectra.

Results: Statistical analysis of the joint OMEGA-THEMIS dataset reveals four spectrally unique geologic units: an exposed Type I region, two Type II deposits, a large dune field concentrated in and extending south of Nili Patera, and the ejecta blankets of nearby craters. However, the Type I terrain is the only common unit when the OMEGA and THEMIS datasets are examined independently (Fig 1). The spectral variations that characterize the Type II terrain are exclusive to the THEMIS dataset (Fig 2). Unique to the OMEGA dataset are the spectral variations that correlate to the extended dune field and ejecta blankets, which reveal stronger absorptions at VNIR wavelengths and decreased band strength at TIR wavelengths (Fig 2).

Preliminary results from MGM analysis indicate a two pyroxene composition with a minor to moderate component of olivine. Average relative abundances for the surrounding terrain, Type II deposits, and the dune field are 60% to 75% high-calcium pyroxene and 40% to 25% low-calcium pyroxene. Compared to these units, the ejecta blankets appear further enriched in high-calcium pyroxene, indicating 80% HCP and 20% LCP. A strongly enhanced 1.2 μm feature suggests that the Type I terrain and the dune field may have a comparatively significant olivine component. This is also supported by an apparent emissivity absorption near 11 μm in the THEMIS data of Type I (Fig 2) [13].

Discussion: Dominant spectral variation in the Nili Patera region of Syrtis Major can be explained by a combination of mineralogy and texture. The spectral uniqueness of the eroded Type I terrain may be attributed to a relative enrichment in olivine, as indicated by the MGM results and the THEMIS spectra. In addition, the MGM results for the relative proportions of HCP and LCP in the Type II terrain are similar to previously derived absolute abundances of 15% HCP and 5% LCP [1]. For spectra of the dunes and ejecta, the increase in absorption band strength at near-infrared wavelengths and decrease in relative band strength at thermal wavelengths may be due to a decrease in particle size [14]. The apparent enrichment of olivine in the dunes, indicated by MGM, suggests that the dominant source for the dune field is the eroded Type I terrain, consistent with the interpretation of [1].

The spectral uniqueness of the Type II terrain at THEMIS wavelengths and the spectral similarity at OMEGA wavelengths demands more careful analysis. Initial results from this study indicate that it is not solely a function of texture because of the obvious emissivity variations. Furthermore, deviations in mafic mineralogy are unlikely because of the spectral similarity at OMEGA wavelengths. A possible explanation is the presence of a silica-rich mineral that is spectrally neutral in the VNIR and active in the TIR. However, geologic evidence makes it difficult to expect a primary magmatic origin of this silica-rich component. For example, while the Type II deposit within Nili Patera appears strongly correlated to a lobate volcanic flow, it superimposes another lobate flow that has no mineralogic Type II signature. Furthermore, another Type II deposit south of Nili Patera is not obviously correlated to any volcanic flow feature. An alternative explanation of the unique mineralogy is a thin, silica-rich surface coating. Further joint investigation of the Type II terrains outside of Nili Patera is anticipated.

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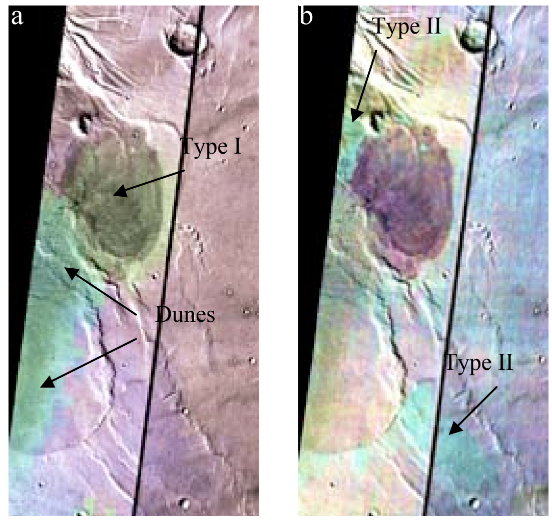

Figure 1. False color images of the spectrally unique geologic units in the Nili Patera region identified by (a) OMEGA using an MNF transform and (b) THEMIS using relative emissivity calculated by [11]. Image centered near 67°E and 8°N.

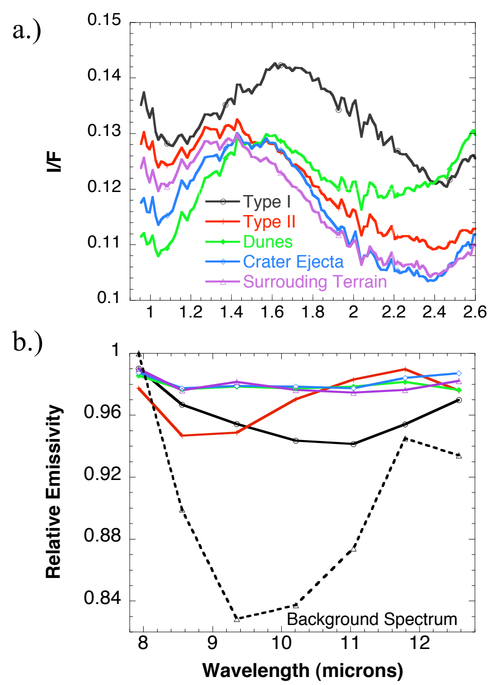

Figure 2. Sample averaged (a) OMEGA spectra and (b) THEMIS spectra of the major spectral units. For the THEMIS data we plot the variation (colored spectra) relative to the common background (dotted spectrum) to enhance apparent differences.