THERMAL INFRARED SPECTROSCOPY OF A SYNTHETIC OLIVINE SERIES (FORSTERITE-FAYALITE) AND INTERPRETATION OF THE NILI FOSSAE, SYRTIS MAJOR, AND ISIDIS REGIONS OF MARS. M. D. Lane[1], T. D. Glotch[2], M. D. Dyar[3], J. L. Bishop[4], C. M. Pieters[5], R. Klima[5], T. Hiroi[5], and J. M. Sunshine[6]; [1]Planetary Science Institute, Tucson, AZ 85705-8331 (lane@psi.edu), [2]Stony Brook University, Stony Brook, NY 11794, [3]Mount Holyoke College, South Hadley, MA 01075, [4]SETI Institute/NASA-ARC, Mountain View, CA 94043, [5]Brown University, Providence, RI 02912, [6]U. Maryland, College Park, MD 20742.

Introduction: Olivine minerals are among the most dominant minerals in terrestrial bodies, and are thus critical to interpretation of planetary spectroscopy. Olivine group minerals most commonly range in composition across the solid solution series between Mg_2SiO_4 (forsterite [Fo_{100}]) to Fe_2SiO_4 (fayalite [Fo_0]). Changes in chemistry across this binary series cause the structure of the mineral to be affected, in turn affecting all types of spectroscopic measurements [1]. Mid-infrared (IR) spectra exhibit systematic changes as a result of changes in vibrations of the constituent molecules across the Mg-Fe olivine solid solution.

Synthetic olivine samples, ranging in composition from forsterite to fayalite [1], have been analyzed using mid-IR thermal emission, mid-IR attenuated total reflection, and mid-IR specular and diffuse reflectance spectroscopy to study the effects of Mg-Fe solid solution. For this abstract, only the results of the thermal emission measurements are presented.

The systematic variations of the emissivity spectra of the Mg-Fe solid solution series are sufficiently large to distinguish differences in olivine composition in remotely sensed data from Mars. Here we present emissivity spectra of the Mg-Fe olivine suite and apply them to the interpretation of Mars Global Surveyor Thermal Emission Spectrometer (TES) data [2] of the olivine-rich Nili Fossae, Syrtis Major, and Isidis Basin regions of Mars.

Sample Description: Olivine samples used for this study were those synthesized by Donald Lindsley at SUNY Stony Brook. For a comprehensive discussion regarding the sample synthesis technique and their compositions, see [1]. The samples vary in composition from forsterite (Fo_{100}) to fayalite (Fo_0) and include the intermediate compositions $Fo_{89.5}$, Fo_{80}, Fo_{75}, Fo_{70}, Fo_{65}, Fo_{60}, Fo_{55}, Fo_{50}, Fo_{40}, Fo_{30}, Fo_{20}, and Fo_{10}.

For this study, the synthesized, finely powdered olivine samples were made into pellets (~5-10 mm-diameter) using a Carver pellet press and die (pressed for ~2 minutes at 18,000 psi). These pelletized discs were analyzed using thermal infrared emission spectroscopy at Arizona State University.

Thermal (Vibrational) Infrared Spectra: The solid-solution olivine spectra are shown in Figure 1. The olivine bands generally migrate to longer wavelengths with increasing Fe content.

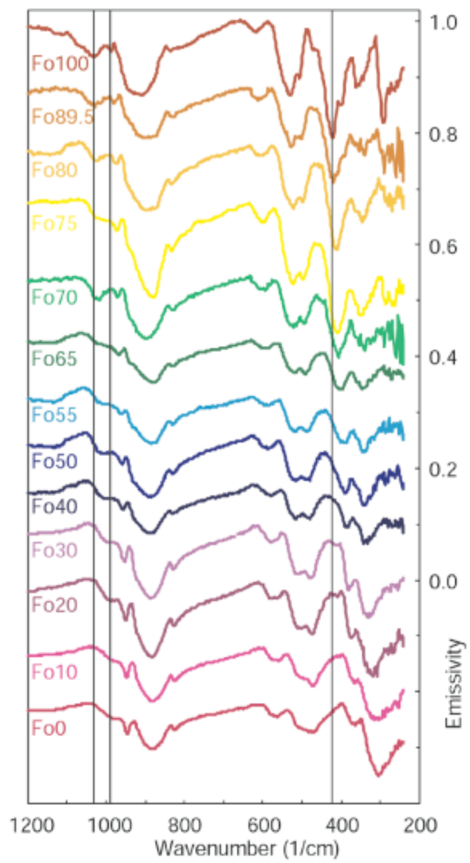

Fig. 1: Thermal emissivity spectra of the Mg-Fe olivine solid-solution series. Vertical lines are included to facilitate comparisons of band positions. The migrating long-wave inflection that lines up with the 422 cm^{-1} vertical line at ~Fo_{40} is the one used for mapping the olivines in this study.

Spectral Index: To map the olivine compositions, a spectral index was developed to accentuate an inflection in the spectra. This local emissivity maximum (flanked by two emissivity minima) migrates with changing composition and is centered at 486 cm^{-1} in the Fo_{100} spectrum and at 395 cm^{-1} in the Fo_0 spectrum.

"High quality" (JMARS-defined [3]) data were mapped for TES OCKs (orbit counter keeper) 0 to 22000. This large OCK range was used because the spectral inflection being mapped lies within a spectral window that is relatively free of atmospheric constituents. Using JMARS, TES data were mapped for each Fo value. Several of these compositional maps are shown in Figures 2 through 5. *All of the images are colored using a similar scale (blue represents less response to the spectral index; red is greater response) and identical index values.*

Results: Because we are using pure synthetic olivine spectra, our determination of the olivine compositions on Mars should be accurate. Our results support the presence of olivine in areas previously determined by others [4,5,6]. This study finds that the Nili Fossae and southern Isidis regions exhibit and are dominated by similar olivine compositions of $Fo_{65/70}$ (Figures 2 and 3); however, the Nili Fossae region also responds to the spectral index for broader olivine compositions of Fo_{50} (and to a lesser extent up to the higher-Mg range of $Fo_{89.5}$), with no olivine at all being mapped in the Nili Fossae region for compositions of Fo_{40} or less. These results are very similar to those of [4,5,6]. However, we did not find the high-iron region in NE Syrtis Major as reported by [4].

In this work, we also identified olivine across much of the Syrtis Major volcanic shield (Figure 4), and found the composition to be ~Fo_{50}, generally more iron-bearing than the Nili Fossae or southern Isidis regions. A small but interesting and unique higher-Fe (Fo_{40}) olivine location was identified at the Syrtis Major central vent (on the eastern edge) (Figure 5).

Fractures and graben structures near Nili Fossae have been partially buried by lava flows from Syrtis Major [7], as supported here (Figure 2) by their similar olivine compositions to the greater Syrtis Major shield.

The mapping of olivine over the basaltic [8] Nili Fossae, Syrtis Major, and Isidis basin areas, demonstrates the abundance of olivine phenocrysts in lavas present over a broad surface region of Mars. Future studies will include application of our olivine spectral indices to the rest of the Martian surface.

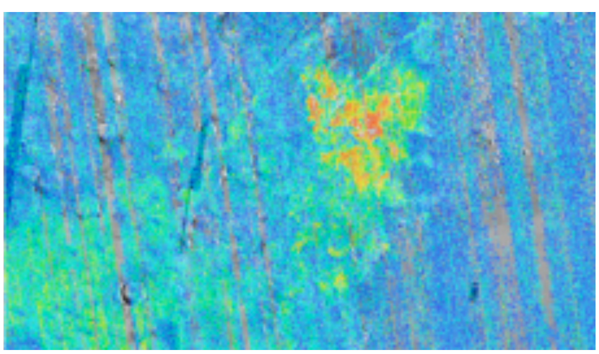

Fig. 2: Fo_{65} spectral index of TES data for the Nili Fossae region (64 ppd).

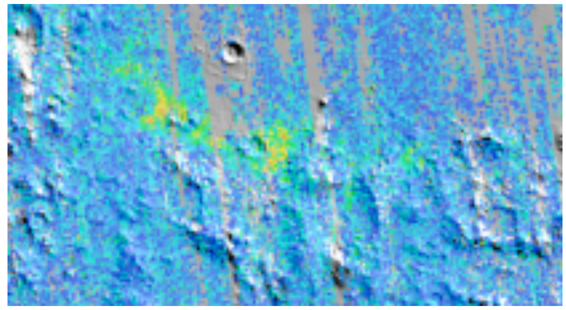

Fig. 3: Fo_{65} spectral index of TES data for the southern Isidis basin region (64 ppd).

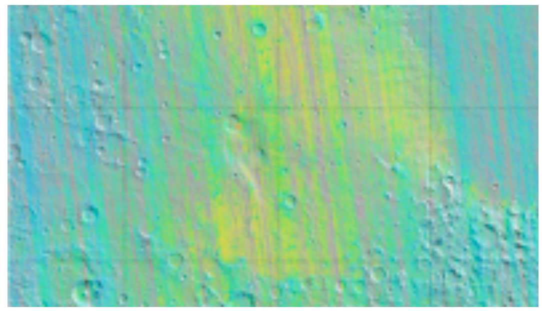

Fig. 4: Fo_{50} spectral index of TES data for Syrtis Major region (32 ppd).

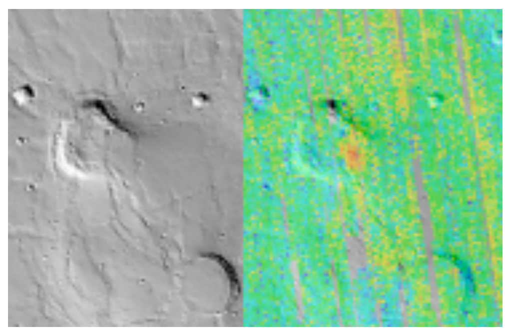

Fig. 5: Syrtis Major shield/central vent. Left: MOLA shaded relief; Right: Fo_{40} spectral index of TES data showing the high-iron olivine region (128 ppd).

References: [1] Dyar M. D. et al. (in revision) *Amer. Mineral.* [2] Christensen P. R. et al. (2001) *JGR, 106,* 23823-23871. [3] Christensen P. R. et al. (2007) *Fall AGU, P11E-01.* [4] Hoefen T. M. et al. (2003) *Science, 302,* 627-630. [5] Hamilton V. E. and Christensen P. R. (2005) *Geology, 33,* 433-436. [6] Koeppen W. C. and Hamilton V. E. (2008) *JGR, 113,* E05001. [7] Raitala J. and Kauhanen K. (1989) *Earth, Moon, Planets, 46,* 243-260. [8] Hamilton V. E. et al. (2003) *Meteor. and Planet. Sci., 38,* 871-885.

Acknowledgments: Thanks are extended to Donald Lindsley at SUNY Stony Brook for synthesizing the olivine samples and to Phil Christensen at Arizona State University for the use of his thermal emission spectrometer facility. This work is supported by MFRP grant #NNX07AR66G and the Mars Odyssey Participating Scientist Program.