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Compositional Variability and Maps of Phobos Based Upon Thermal Emission Spectra

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Abstract

We provide a crude map of the compositional variability on Phobos using thermal emission spectra.

1. Introduction

The origin of the Martian moon Phobos is a long-standing enigma. Addressing the composition of Phobos helps constrain various theories of its formation; asteroid capture, in-situ formation, formation from Mars ejecta [see 1,2]. Visible and near-infrared spectra of Phobos do not exhibit deep distinctive absorption features, making compositional interpretation a tricky task. Observations in the thermal infrared (tir) exhibited several spectral features that were used to investigate the composition of the surface [3]. The tir observations were obtained by Mars Express – Planetary Fourier Spectrometer [PFS, 4] and Mars Global Surveyor Thermal Emission Spectrometer [TES, 5] instruments.

Table 1. TES and PFS Phobos Observations

Inst-Orbit #	Phase angle[a] (deg)	Pixel / km[b]	# of spectra
TES-476	105-107	12	6[c]
TES-501	110-113	9	9[c]
TES-526	93-149	10	106[c]
TES-551	51-131	2-7	59[c]
PFS-756	64	8	2
PFS-5851	97	5	1
PFS-5870	52	17	1
PFS-6906	35	26	2

[a]sun-phobos-spacecraft, [b]approximate pixel size for TES and field-of-view diameter for PFS, [c]with TES T_{bol} >230° K and pixel filling factor >0.7.

Table 1 lists the observations of Phobos obtained during various orbits of PFS and TES data. Both instruments observed Phobos multiple times providing a range of surface spatial resolutions. Most encounters yielded only a few spectra, however TES obtained several tens of spectra on two occasions. Unfortunately, during orbit 526 the observations were of the un-illuminated portion of the surface. Here we expand on the initial report of Giuranna et al. [3] by providing a crude map of the distribution of materials on Phobos.

2. Compositional Interpretation and Mapping

There are many factors complicating the interpretation of observational tir data obtained from airless objects whose surfaces are not at temperatures reproduced in the laboratory. However, Giuranna et al. [3] provide a qualitative interpretation of the spectral data.

Roush and Hogan applied a K-Means clustering to TES data from orbit 551 [6]. The clustering combines spectra with similar properties into groups and reports the statistical information associated with each, e.g. mean and variance. Most spectra fell into one of four groups that are spatially associated with areas located on the rim and floor; in the grooves to the east, and to the northeast, of Stickney crater. Average emissivities of the four regions were used as representative spectral measurements in the compositional efforts. The locations of these four regions are shown in Figure 1. A compositional analyses of these averages was performed via comparison to a variety of spectral libraries. The result listed the top ten matches to the Phobos data [6]. These are indicated for each region in Figure 1. The results are dominated by phyllosilicates, with a few indications of tecto- and nesosilicates.

Locations of the PFS observations are shown in Figure 2. Giuranna et al. [3] performed a similar compositional comparison for the PFS and TES data. Analyses of TES data confirm previous results of [6]. Results for PFS observations are labeled in Figure 2.

Where the PFS and TES observations overlap near Stickney, the compositional results are mutually consistent, even with a time separation of 15-20 years.

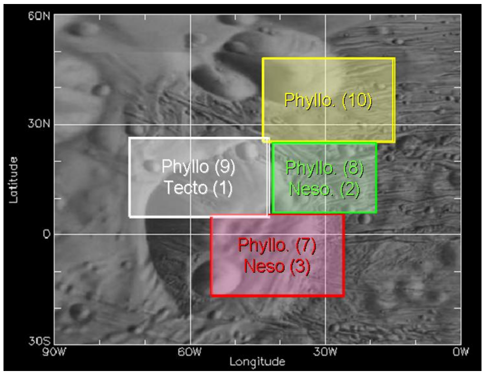

Figure 1: TES spectra (orbit 551) yield 4 distinct spectral clusters near Stickney Crater. Each colored box approximates the region containing several spectra. The labels of each box are the minerals representing the ten best matches to the average of each spectral cluster. Phyllo = phyllosilicates, Neso = nesosilicates, and Tecto = tectosilicates.

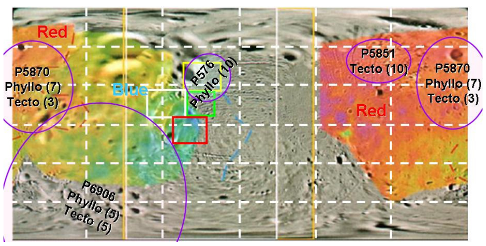

Figure 2: PFS data locations on Phobos (purple outlines), the base map includes the color units of Murchie et al. [7]. The labels for each orbit indicate the ten best minerals that best match the PFS data. Phyllo = phyllosilicates and Tecto = tectosilicates. The colored boxes for the TES data, shown in Fig. 1, illustrate the consistent mineralogical interpretation based on the two instruments.

3. Summary and conclusions

Two independent instruments (PFS and TES) measured the thermal infrared emissivity of Phobos The data obtained exhibit spatial variability on the surface of Phobos.

The results, based upon the tir data, suggested that the spectra of individual locations on Phobos are consistent with the presence of phyllosilicates, although some nesosilicates and tectosilicates are also suggested [3]. Phyllosilicates are particularly prevalent in the area northeast of Stickney [1,6] that corresponds to the *blue* unit defined by Murchie et al. [7]. Analysis of PFS observations sampling the *red* unit defined by Murchie et al. [7] is consistent with tectosilicates, especially feldspars and/or feldspathoids [3] and perhaps their mixing with phyllosilicates.

The TES observations of regions near Stickney defined by the statistical clustering contain multiple spectra. This means there is an opportunity to provide higher spatial mapping of the composition around Stickney.

References

[1] Burns, J.A., 1992. Contradictory clues as to the origin of the martian moons, in Mars, H. Kieffer et al. Eds., Univ. Arizona Press, Tucson, Arizona, USA, pp. 1283-1301.

[2] Craddock, R.A., 2011. Are Phobos and Deimos the result of a giant impact?, Icarus 211, 1150-1161.

[3] Giuranna, M. , Roush, T.L., Duxbury, T., Hogan, R.C., Carli, C., Geminali, A. and Formisano, V., 2011. Compositional interpretation of PFS/MEx and TES/MGS thermal infrared spectra of Phobos, Planet. Space. Sci., in press, doi: 10.1016/j.pss.2011.01.019

[4] Formisano, V., et al., 2005. The Planetary Fourier Spectrometer (PFS) onboard the European Mars Express mission. Planet. Space Sci. 53, 963–974.

[5] Christensen, P.R., et al., 1992. Thermal emission spectrometer experiment: Mars Observer Mission. J. Geophys. Res. 97, 7719–7734.

[6] Roush, T., and Hogan, R., 2001. Compositional Variability Associated with Stickney Crater on Phobos, Lunar Planet. Sci. Conf. 32, Abstract #1915, Lunar & Planetary Inst., Houston.

[7] Murchie, S., Thomas, N., Britt, D., Herkenhoff, K., Bell III, J.F., 1999. Mars pathfinder spectral measurements of Phobos and Deimos: comparison with previous data. J. Geophys. Res. 104, 9069–9079.