PRELIMINARY IDENTIFICATION OF MINERALS IN SILT- AND SAND-SIZE GRAINS ON MARS FROM PHOENIX OM IMAGES USING THREE-CHANNEL COLOR PHOTOMETRY. M. A. Velbel[1], W. Goetz[2], M. H. Hecht[3,4], S. F. Hviid[2], M. B. Madsen[5], W. T. Pike[6], and U. Staufer[7], [1]Department of Geological Sciences, Michigan State University (East Lansing, MI 48824-1115; velbel@msu.edu), [2]Max Planck Institute für Sonnensystemforschung (31977 Kathlenburg-Lindau, Germany; goetz@mps.mpg.de), [3]Jet Propulsion Laboratory, Caltech, Pasadena, CA, USA, [4]MIT Haystack Observatory, Westford, MA, USA, [5]Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark, [6]Department of Electrical and Electronic Engineering, Imperial College, London, UK, [7]TU Delft, Micro and Nano Engineering Laboratory, Delft, The Netherlands.

Introduction: The Microscopy, Electrochemistry and Conductivity Analyzer (MECA) on Phoenix Mars Lander (PHX) included an Optical Microscope (OM) that returned color images of soil material with a spatial resolution of 4 μm/px [1]. The OM consists of a high-resolution imaging system and an active visible-light sample illumination system composed of three LEDs: Blue (B, λ ~465 nm), Green (G, 524 nm), and Red (R, 636 nm) [1]. The upper limiting grain-size imaged (200 μm) was determined by the sieve through which sample was introduced by the Phoenix Robotic Arm (RA) into the MECA instrument; the lower limiting size was determined by the 4 μm / pixel limit of the optical system [1]. Fine- and very- fine sand (200-62.5 μm) and all but the finest silt (62.5-4 μm) were imaged for eight samples from different portions of the periglacial landforms within the Phoenix RA's workspace [2]. Color OM images were used to develop a taxonomy of soil particles, to describe their optical and magnetic properties [2,3], and, together with measurements from the PHX Atomic Force Microscope (AFM; [1]), to determine the particle size distribution [4]. Strong variation in the red reflectance (λ = 630-710 nm) from particle to particle leads to the following classification (grain types listed in order of decreasing abundance (in vol. %); red and white fines, brown sand, and black sand [2].

Both mechanical (fracture [2]) and chemical [5] origins have been proposed for surface textures on brown and black sand grains imaged by the PHX OM. However, the PHX science payload did not enable acquisition of correlative solid-phase compositional, spectroscopic, or crystal-structure data and therefore did not support direct identification of the mineralogy of these grains. Because different minerals have different physical and reactive properties, interpretations of chemical and / or physical processes that gave rise to observed grain attributes are presently limited by lack of knowledge of the specific minerals present in the grains imaged by the Phoenix OM (and AFM [6]).

This presentation reports preliminary results of efforts to constrain the range of possible mineral phases present in brown grains of the coarsest-grained fractions of PHX samples from OM imagery.

Analysis: We assembled 3-point reflectance spectra for three brown grains from surface sample Rosy Red (delivery sol 26; red image OS033RGB899154125_13BD0MRR2 and associated green and blues images, acquired on sol 33 [2]; Figure 1) with a fixed set of calibration parameters.

Results: Figure 2 shows the signals produced by the three colors of LEDs used to illuminate samples in the Phoenix OM. Widths of colored bars correspond to the wavelength range produced by the LED. Heights of the colored bars correspond to the entire (composite) range of R* for the three brown grains processed for this preliminary study.

Discussion: Comparison of three-channel "spectra" for these PHX brown grains with a widely used spectral library [7] reveals several plausible matches. PHX OM photometry is consistent with library spectra for ferroan (Fo_{11}) olivine (Figure 2 top) and possibly also Fo_{18} and Fo_{29} (not shown; all prepared as <60 μm grains); nanohematite (Figure 2 center) and some other varieties of hematite (not shown); and / or some library jarosites (Figure 2 bottom). It is more likely that the brown grains consist of olivine with nanohematite and / or jarosite coatings rather than that silt- and very-fine-sand-size particles consist entirely of nanohematite and / or jarosite. Three-channel "spectra" for these three PHX brown grains are *inconsistent* with library spectra [7] (not shown) of most olivines $Fo_{\geq 41}$ prepared as <60 μm grains, and coarser (160 μm) olivine; fine-grained (<10 μm) or thin-film hematite; magnetite; goethite; and most library jarosites.

Fayalitic olivine similar to that identified at the PHX landing site on the Martian arctic northern plains has been identified in Jezero Grater [8] and elsewhere in and near Nili Fossae [9,10]. Olivines compositionally consistent with PHX data ($Fo_{<41}$) occur in nakhlites ($Fo_{14\text{-}43,}$ [11]). The two secondary minerals tentatively identified at the PHX landing site, nanohematite and jarosite, are among the candidate constituents of nanophase oxides (npOx) identified elsewhere on Mars by Mössbauer spectroscopy [12].

Conclusions: We have begun reanalyzing microscopic images of soils at the PHX landing site in terms of 3-point reflectance spectra (465 nm, 524 nm, 636 nm). Based on comparison of these spectra with library spectra, grains of Martian (PHX) soil particles consist mainly of olivine ($Fo_{<40}$), nanohematite, and / or jarosite. All spectrum-dominating minerals permitted by preliminary matches with library spectra within the OM illumination system's narrow spectral range (440-640 nm) are reasonable in light of previous mineral identifications using data from other Mars missions [8-10,12] and Mars meteorites [11]. Sand- and coarse-silt-size particles at the Phoenix landing site (both brown and black sand) are very diverse [1,2] and may well justify further taxonomic subdivision.

References: [1] Hecht M. H. et al. (2008) *JGR*, *113*, E00A22. [2] Goetz W. et al. (2010) *JGR*, *115*, E00E22. [3] Goetz W. et al. (2009) *LPS XL*, Abstract #2425. [4] Pike W. T. et al. (2011) *GRL*, *38*, L24201. [5] Stoker C. R. et al. (2010) *JGR*, *115*, E00E20. [6] Velbel M. A. and Losiak A. I. (2010) *JSR*, *80*, 771-780. [7] USGS Spectral Library: http://speclab.cr.usgs.gov/spectral.lib04/spectrallib.desc+plots.html. [8] Ehlmann B. L. et al. (2008) *Nature Geosci.* 1, 355-358. [9] Ehlmann B. L. et al. (2008) *Science*, *322*, 1828-1832. [10] Hoefen T. M. et al. (2003) *Science*, *302*, 627-630. [11] Treiman A. H. (2005) *Chem. der Erde*, 65, 203-270. [12] Morris R. V. et al. (2006) *JGR*, *111*, E02S13.

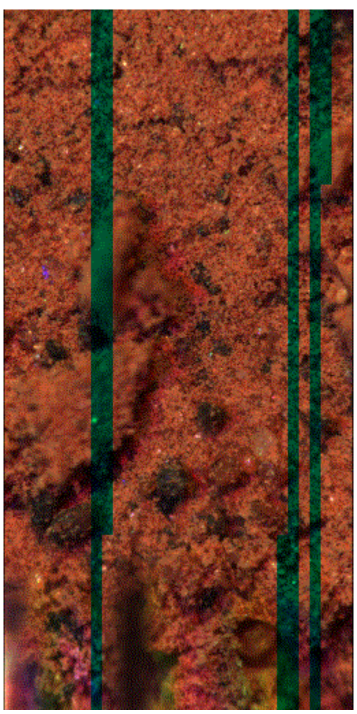

Figure 1: Phoenix OM image of surface sample Rosy Red (delivery sol 26; red image OS033RGB899154125_13BD0MRR2 and associated green and blues images, acquired on sol 33 [2])

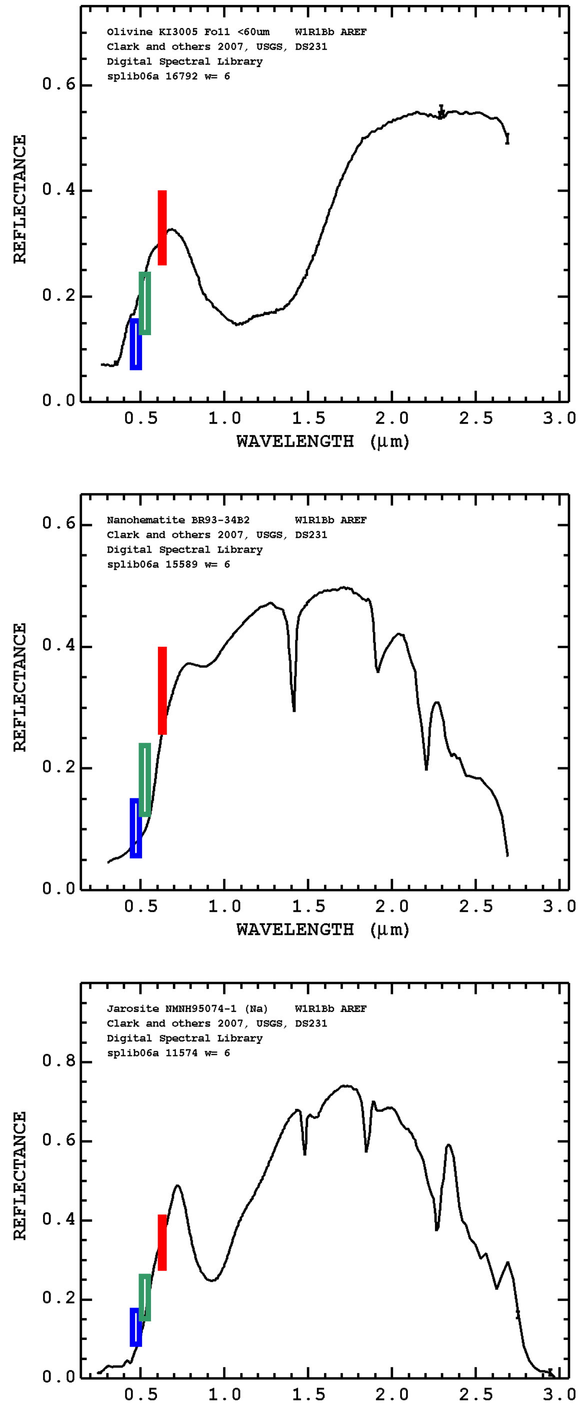

Figure 2: Box width and height correspond, respectively, to the wavelength range produced by the LED to illuminate samples and the entire (composite) range of R* for three brown grains. Observations are compared with library spectra [7] for ferroan (Fo_{11}) olivine (top), nanohematite (middle), and jarosite (bottom).