VNIR EFFECTS OF SPACE WEATHERING: MODELING STRONG ABSORBERS IN A SCATTERING MATRIX. C. Legett IV[1], T. D. Glotch[1] and P. G. Lucey[2], [1]Geosciences Department, Stony Brook University 255 ESS Building, Stony Brook, NY 11794-2100 carey.legett@stonybrook.edu, [2]Planetary Geosciences/SOEST, University of Hawaii.

Introduction.

Previous Work. Nanophase iron ($npFe^0$) bearing rims on lunar regolith particles have been identified as the product of space weathering processes, including solar wind sputtering/implantation and micrometeoroid bombardment [1]. The spectral effects due to $npFe^0$ appear to be dependent on the abundance and size of the $npFe^0$ particles [2,3]. Laboratory work with lunar soils and analog materials has shown that if the $npFe^0$ is less than approximately 50 nm in size, the overall effect will be to both redden and darken the spectra whereas larger $npFe^0$ particles lead to only darkening without reddening [4].

Recent modeling efforts based on Mie theory and Hapke's radiative transfer model [5] have been successful at reproducing laboratory spectra using Maxwell-Garnett effective medium theory with empirical corrections [2]. These modeling efforts have not yet fully reproduced the transition from darkening and reddening to only darkening with the $npFe^0$ grain sizes indicated by laboratory work. In the models, the transition occurs at approximately 300 nm instead of 50 nm [3].

Multiple Sphere T-Matrix Model. We are investigating the use of the Multiple Sphere T-Matrix (MSTM) model to improve upon the success of the previous Mie-Hapke models and to resolve the $npFe^0$ grain size discrepancy. The MSTM model is a first-principles, direct simulation method for calculating an exact analytical solution to the time-harmonic Maxwell's equations for multiple sphere systems [6]. Our previous work shows that the MSTM/Hapke approach improves the modeled spectra of fine particles over Mie/Hapke methods [7].

Methods.

Model and Theory. We model the space weathered, iron bearing rims as silica gels containing spherical nanophase iron particles. These gels are collections of nanoscale silica spheres with a packing density roughly equivalent to the porosities indicated in laboratory work. A second approach is to generate a single large sphere to represent the silica gel, apply effective bulk optical constants given the porosity, and populate it with $npFe^0$ particles to reach the desired iron content.

In the first approach, we generate a spherical volume containing several thousand spheres using PackLSD molecular dynamics software [8,9] and assign an index of refraction (n) and extinction coefficient (k) to each sphere depending on the phase it is intended to represent and the wavelength we are modeling. Wavelength-dependent optical constants for Fe^0 are taken from [10] while those for silica are from [11]. Where necessary, we apply either a sixth order polynomial or piecewise linear fit to interpolate between provided n and k values from the literature over our model spectrum range (700-1700 nm, 100 nm steps).

We take the output of the MSTM model at each wavelength analyzed and extract the scattering and extinction efficiencies and calculate single scattering albedo and use it to calculate the bidirectional reflectance via a simplified Hapke bidirectional reflectance model [5].

Results. We ran 23 model runs with between 0.0057 and 19.65 wt% iron with iron particle sizes between 20 and 300 nm. A broad parameter space with iron particles smaller than 100 nm and iron contents from ~0.5 to 8 wt% Fe show relatively steep red slopes in the 700-1700 nm region. Runs outside of this region show flatter spectra, and by 300 nm, spectra are effectively flat.

Discussion: These results are consistent with previous modeling efforts but do not yet constrain the size at which the transition from reddening and darkening to darkening only.

Future work and Conclusions: More runs will be conducted to constrain the transition region. Additionally, more runs will be conducted with very small (<10 nm) particle sizes and very low iron contents to further examine the behavior of the system at these conditions. Companion laboratory work using an aerogel matrix with carbon black and iron nanopowder absorbers is also currently ongoing and will contribute to the interpretation of the modeling results.

References:

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