RAYLEIGH SCATTERING IN REFLECTANCE SPECTRA OF THE MOON

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Introduction: Space weathering causes a darkening and reddening of reflectance spectra [1 and references therein] due to nanophase iron ($npFe^0$). Noble *et al.* [1] conducted controlled experiments and showed $npFe^0$ <10nm produced reddening, while >40nm particles produced darkening. Lucey and Noble [2] showed that a major factor in the reddening is due to Rayleigh absorption. However, both studies [1, 2] showed a strong increase in observed reflectance toward blue wavelengths in some samples that remain unexplained and not modeled. Clark *et al.* [6] showed spectra of laboratory samples of geologic materials that display Rayleigh scattering and they constructed mixtures using 200 nm diameter particles showing the Rayleigh scattering effect.

Data from the Moon Mineralogy Mapper (M^3) [3] show the common red lunar spectra due to $npFe^0$ (Figure 1). We removed thermal emission and a linear continuum using the reflectance at 1.47 and 2.7 microns from M^3 spectra and searched for evidence of enhanced blue reflectance. We find that some lunar spectra show very strong blue enhancements (Figure 2).

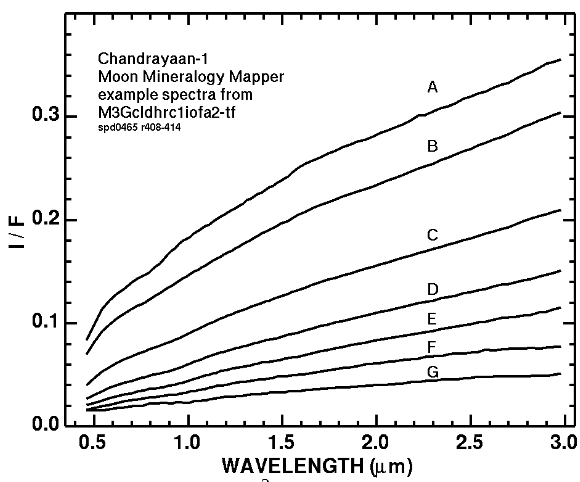

Figure 1. Typical M^3 spectra of mature lunar soils showing the red, approximately linear slope due to absorption by fine-grained metallic iron in the lunar soils. These spectra have had a model thermal emission removed.

Following [2], Rayleigh absorption is modeled using equations 11 and 12 from [4]. Rayleigh scattering was computed using equation equations 5.13, 5.14 in [5], p. 73.

Models using a transparent medium containing Rayleigh absorbers produce the linear red slope typical of spectra of mature lunar soils. Addition of Rayleigh scatterers to the model produce the increased blue reflectance similar to that seen in M^3 data (Figure 3). The size and particle distribution still needs exploration, and the results in Figure 3 are not necessarily unique.

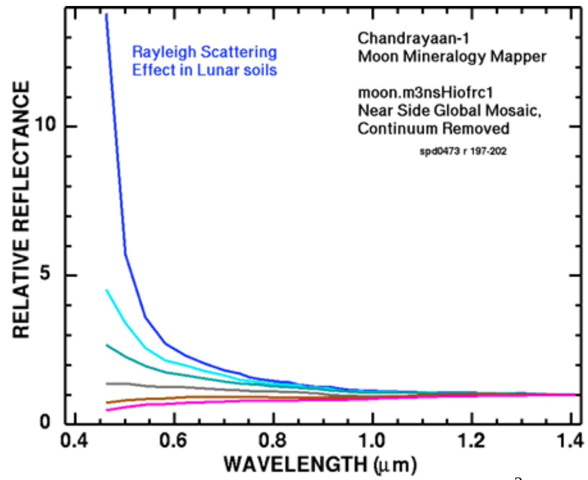

Figure 2. Continuum-removed lunar M^3 spectra showing a blue enhancement due to Rayleigh scattering by sub-micron particles in the lunar soil.

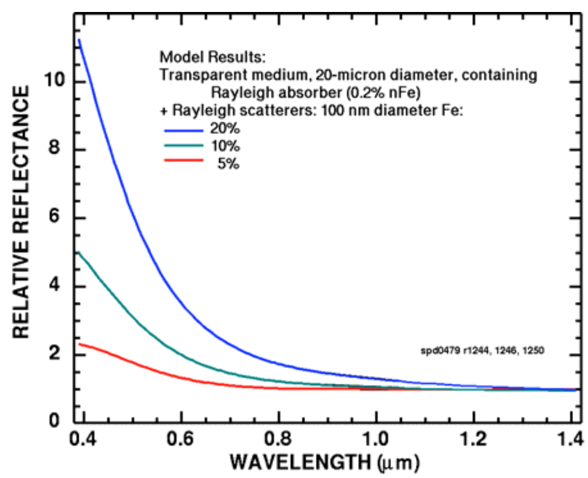

Figure 3. Model spectra showing effects of Rayleigh scattering in the surface. The results are not necessarily unique.

A map of the Rayleigh scattering effect is shown in Figure 4. The results show that the scattering effect is strongest in the Mare. This might be expected due to the higher iron content of the basalts, allowing for creation of more iron particles from space weathering.

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References:

[1] Noble *et al*. *Icarus*, 2007, **192**, 629-642
[2] Lucey and Noble (2008) *Icarus* **197**, 348-353.
[3] Pieters *et al.* (2009) Science **326**, 568-572.
[4] Hapke (2001) *JGR*, **106**, 10039-10073.
[5] Hapke (1993), Cambridge University Press.

[6] Clark *et .al.* (2008), *Icarus*, **193**, 372-386.

Figure 4. Map of the Rayleigh scattering effect on the moon from M^3 data.