

Experimental Study of the Porosity Dependence of a Planetary Regolith Analog. B. W. Hapke¹, R. M. Nelson², W. D. Smythe² and K. Mannatt², ¹Dept. Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260, hapke@pitt.edu, ²Jet Propulsion Laboratory, Pasadena, CA 91109.

It is not widely appreciated that the reflectance of a particulate medium such as a planetary regolith depends on the porosity. A recently-developed model [1] accounts for this effect quantitatively. It predicts that the reflectance of a high albedo powder is virtually independent of porosity, but that the reflectance of a low albedo powder increases as the filling factor f increases if $f < \sim 50\%$. However, if $f > \sim 50\%$ coherent interactions between particles are predicted to become important, so that clumps and chains of particles begin to act like larger single particles, and the reflectance decreases as f increases.

To study these effects we have measured the bidirectional reflectance of a sample of SiC abrasive powder with a mean particle size of about $17\ \mu\text{m}$ using the JPL goniometric photopolarimeter [2]. The angle of incidence was $i = 0$; the viewing angle e and phase angle $g = e$ varied between $0 < g < 22^\circ$. We measured the sample in three conditions of packing: sifted ($f = 0.22$), poured ($f = 0.42$) and pressed ($f = 0.66$). Fig. 1 shows the reflectances I/F vs g of the samples relative to the reflectance of a commercial PTFE standard at $i = 0$ and $e = 5^\circ$. As predicted, the reflectance of the higher density poured sample is larger than that of the lower density sifted sample. However, the filling factor of the pressed sample exceeds the critical value for the onset of coherent effects, and, as predicted, its reflectance is lower than the other two samples.

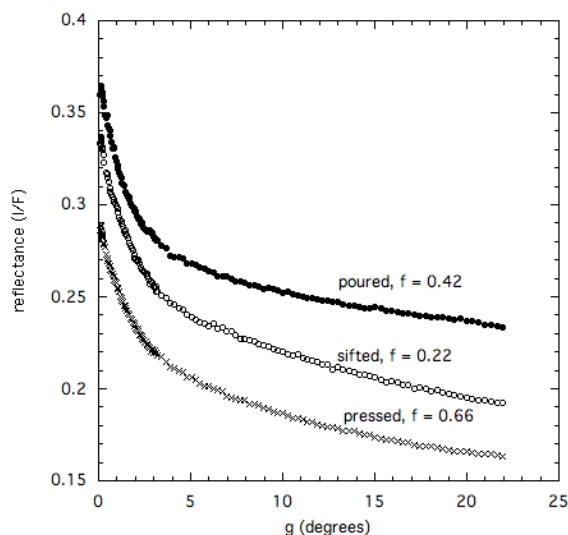


Fig. 1. Reflectance vs phase angle.

All of the curves exhibit a relatively gradual increase as g decreases for $g > 5^\circ$. We interpret this increase as a shadow-hiding opposition effect (SHOE), because the circular polarization ratio (CPR) (ratio of the reflectance with the same helicity as the incident irradiance to that with the opposite helicity) decreases as g decreases (Fig. 2), which is the signature of a SHOE [3]. The samples also exhibit an abrupt non-linear increase for $g < \sim 5^\circ$ within which the CPR in-

creases as g decreases (Fig. 2), indicating that this peak is a coherent backscatter opposition effect (CBOE) [3].

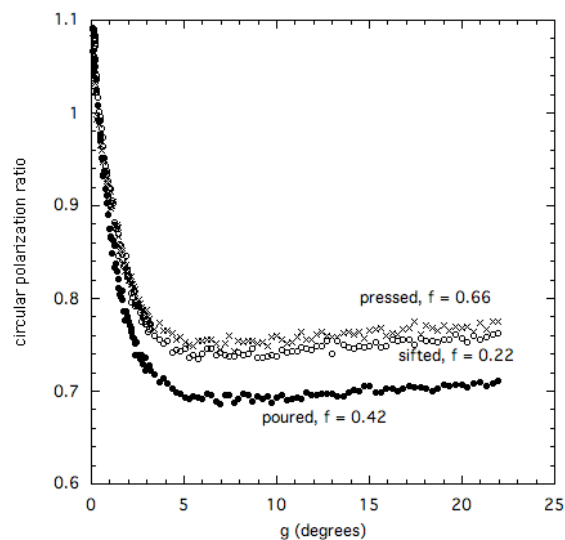


Fig. 2. Circular polarization ratio vs phase angle.

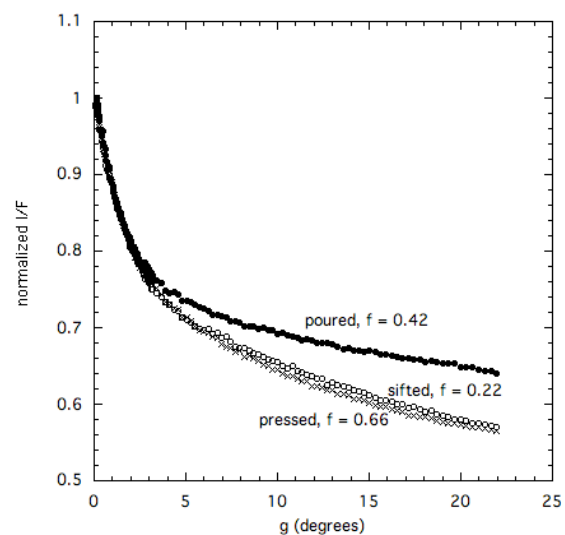


Fig. 3. Reflectances normalized to 1.00 at $g = 0.1^\circ$.

Fig. 3 shows the reflectances normalized to $g = 0.1^\circ$. Note that the CBOE peaks are virtually indistinguishable. Present CBOE theory predicts that the widths of the peaks should increase as f increases if the peak is controlled by scattering between the particles. However, the lack of dependence on f implies that the CBOE is controlled primarily by scattering from surficial and internal imperfections of the individual particles, rather than the spacing between particles. Models of the CBOE that do not take this into account are unreliable. Apparently the CBOE of a planetary regolith

is giving information about the nature and structure of the particles of the soil.

Fig. 4 shows the linear polarization of the poured sample. To avoid clutter only the data for the poured sample are shown, but the other two are similar. Note that the polarization curve has two distinct minima: a narrow one centered at about 3° , which is caused by the CBOE [4], and a second broader minimum centered at about 9° that appears to be associated with the SHOE. The broad negative polarization minimum is exhibited by most of the bodies of the solar system, but has never been satisfactorily explained.

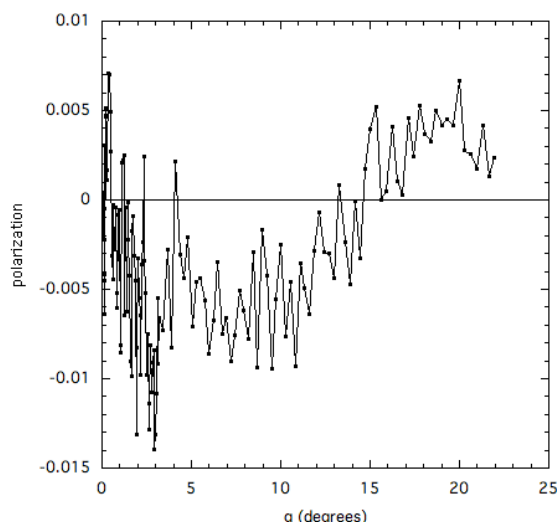


Fig. 4. Negative branch of polarization of the poured sample.

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