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Laboratory optical measurements of particulate surfaces with various brightness

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We present results of laboratory optical measurements of volcanic sand, salt and their mixtures at three different volume ratios. We investigate interrelation between brightness of the samples and their phase function and polarization characteristics. The samples were illuminated using an artificial light source, whose spectrum and polarization resemble what is in the sunlight. Characteristics of the scattered light were measured with the Finnish Geodetic Institute field goniospectropolariphotometer FIGIFIGO [1] at phase angle spanning the range from –20° to 120° (except for the angles from –6° to 6°), and at wavelengths 350–2500 nm. The studied samples reveal significant difference in their appearance. Reflectance at phase angle of 6 ° varies from 4% (in pure volcanic sand) to 86% (in pure salt) as compared to equivalent Lambertian surface. We found that the volume ratio of salt and volcanic sand affects the phase function of the sample. While samples are getting brighter, their phase function flattens, at least over the studied range of phase angle.

Relative amount of dark and bright components unambiguously affects angular profile of the degree of linear polarization. Amplitude of positive polarization branch P_{max} at side scattering is as high as $\sim$50% in the pure volcanic sand; whereas, in the pure salt it is only $\sim$1%. In the mixtures, maximum of linear polarization takes on intermediate values. It is important that the transition from P_{max} in the darkest sample to the one in the brightest sample appears to be monotonic, suggesting a systematic inverse correlation between P_{max} and reflectance of the sample. Thus, our experimental results are in a good agreement with the *Umov law* [2], which states an inverse correlation of albedo and maximum of linear polarization. Interestingly, phenomenon of the negative polarization near backscattering (phase angle $< 30^{\circ}$) is less affected by the volume fraction of volcanic sand and salt compared to what we see in the positive polarization branch. Nevertheless, we note that amplitude of the negative polarization tends to decrease while the reflectance increases. One can conclude, therefore, the stronger multiple scattering among constituent particles yields the weaker negative polarization in particulate medium.

References: [1] J.I. Peltoniemi, T. Hakala, J. Suomalainen, E. Honkavaara, L. Markelin, M. Gritsevich, J. Eskelinen, P. Jaanson, E. Ikonen. J. Quant. Spectrosc. Radiat. Transf. 146, 376–390 (2014); [2] Yu.G. Shkuratov, N.V. Opanasenko. Icarus 99, 468–484 (1992).