**EXPERIMENTAL INVESTIGATION OF THE POTENTIAL WAVELENGTH DEPENDENCE OF HAPKE PARAMETERS IN THE VISIBLE AND NEAR INFRARED RANGE.** A. M. Cord, P. C. Pinet, Y. Daydou and S. Chevrel, UMR 5562 / OMP/GRGS/CNRS, 14 av. E. Belin, Toulouse, 31400 France, Aurelien.Cord@cnes.fr.

**Introduction:** The semi-empirical model developed by Hapke [1] is widely used to analyze reflectance data from planetary surfaces (e.g. [2], [3], [4]). It requires the knowledge of six parameters to calculate the bidirectional reflectance. Its application relies on some physical quantities characterizing the optical properties of the materials under examination: the phase function, the opposition effect, and the roughness. All the parameters involved in this model, except the single scattering albedo, are generally considered to be independent of the wavelength [1]. However Shepard and Campbell [5] made the hypothesis that the value of Hapke's parameters may differ for the same surface at different wavelengths and suggested that the full Hapke model could be fitted to observations of a single surface observed in multiple wavelengths. The purpose of this study is to explore this approach. We have a particular interest in looking at the potential spectral dependence of each parameter.

**Experiment description:** We work with multi-angular measurements acquired by a new laboratory wide-field multispectral imaging facility [6], simulating angular conditions of observation in planetary exploration for spaceborne optical instruments. 18 narrow band interferential filters are used for measurements in the spectral range 0.4 to 1.05 μm.

Ten angular configurations are selected with incidence angles between 0° and 55° and emergence angles between -70° and 70° in the principal plane, in order to span the photometric variability. The minimum phase angle is 20°.

We select for this study three different samples: a fresh unaltered basalt with grain size less than 75 μm, labeled "Basalt", a highly altered basalt, palagonitic-like material with grain size from 250 to 500 μm, labeled "Palagonite" and an oxidized basaltic red-tephra, with grain size from 500 μm to 2 mm, labeled "Tephra".

We derive parameter values for these three analog samples of planetary regolith surfaces, minimizing the difference between the measured and modeled spectra [7]. The method used to retrieve the parameters is presented in a companion abstract [8]. We then study the possible variation of parameter values as a function of wavelength.

**Results:** *Phase function:* we use the double Henyey-Greenstein function, including two parameters (b and c), to describe the particle phase function P(g):

$$P(g) = (1-c)\cdot\frac{1-b^2}{\left(1+2b\cdot\cos(g)+b^2\right)^{3/2}} + c\cdot\frac{1-b^2}{\left(1-2b\cdot\cos(g)+b^2\right)^{3/2}}$$

Figure 1 shows the wavelength dependence for these two parameters. The b parameter remains almost constant in our range of wavelengths; the variations are on the order of the confidence estimate we have established and show no specific trend (fig 1a).

For Palagonite and Tephra, the c parameter shows a weak but systematic increase as a function of wavelength. On the contrary, for basalt, it decreases from 0.125 to 0.105 (fig 1b). This is a second order effect, indicating a relative variation in the contribution of backward scattering versus forward scattering.

*Shadowing function:* From new laboratory observations on natural surfaces we show (figure 2) a 10 to 15% decrease of the shadowing function parameter as the wavelength increases. This second order variation confirms the assumption of [5]. We hypothesize that this arises from the diffraction effect: indeed the proportion of particles, which are smaller than the wavelength and therefore do not contribute anymore to the shadowing effect, increases with the wavelength.

*Backscattering function:* the opposition effect is undetectable for phase angles greater than 20°. Therefore no wavelength dependence study has been carried out.

**Conclusion:** These results, although derived from measurements made in the principal plane, strengthen the case that the implicit assumption that Hapke's parameters are constant with wavelength is not totally valid. Indeed, it would be worth extending this preliminary exploration toward the infrared. Our results also highlight the need for an improved interpretation of this dependence.

**References:** [1] Hapke B. W. (1993), Cam. Univ. Press, [2]. Johnson P. E (1983), *JGR*, *88,* 3557-61, [3] Helfenstein P. and Veverka J. (1987), *Icarus*, *72*, 342-357, [4] Cheng A. F. and Domingue D. L. (2000), *JGR*, *105*, E4, 9477-9482, [5] Shepard M. K. and Campbell B. A. (1998), *Icarus, 134*, 279-291, [6] Pinet P. et al. (2001), LPSC XXXII, Abstract #1552, [7] Cord A. et al., *Icarus*, under revision, [8] Cord A. et al, this volume.

**Figure 1a: Wavelength dependence of the b parameter (phase function):**

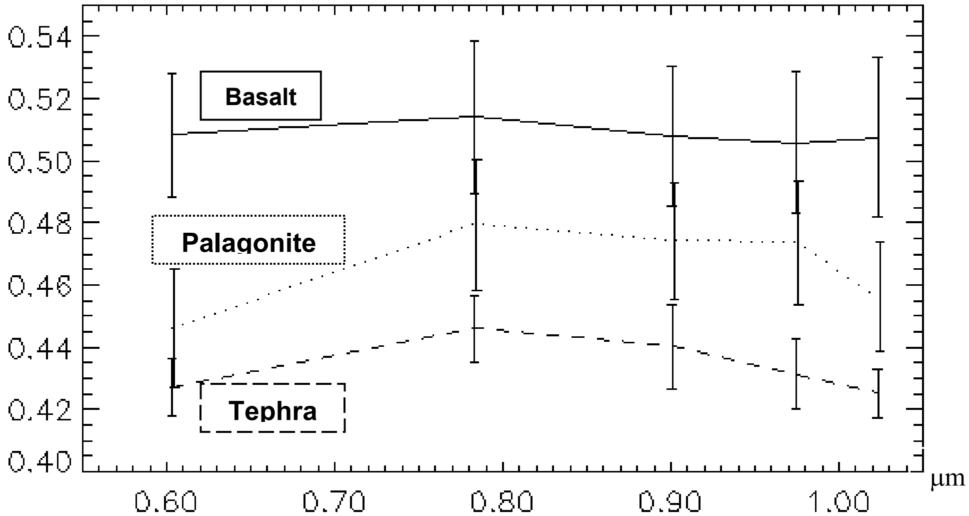


**Figure 1b: Wavelength dependence of the c parameter (phase function):**

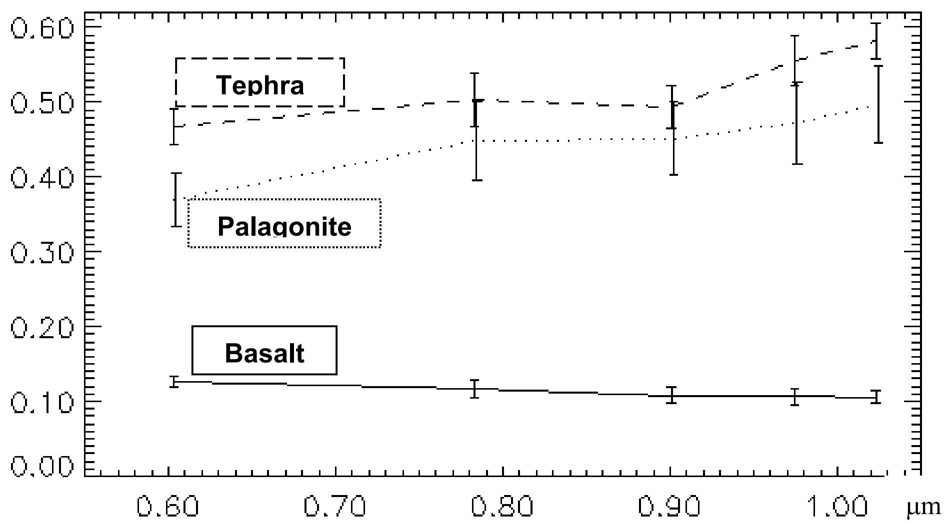


**Figure 2: Wavelength dependence of the shadowing function parameter.**