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Lunar Meteoroid Ejecta Engineering Model

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2.1 Porosity

The lunar regolith porosity is related to the amount of free space between individual grains. The greater the porosity, the more void space is present. Table 3.4.2.3.4-1 of the DSNE gives values of the porosity as a function of depth down to 60 cm derived from Apollo core measurements (copied from Table 9.5 of the Lunar Sourcebook) and shown here in Table 1.

Table 1: Porosity for various depths.

Depth Range (cm)	Average Porosity, n (%)
$0-15$	52 ± 2
$0-30$	49 ± 2
$30-60$	44 ± 2
$0-60$	46 ± 2

2.2 Density

The bulk density (ρ) of the lunar regolith is defined as the mass of material in a given volume, which relates the particle density (ρ_p) and porosity (n) to the bulk density as (see Section 3.4.2.3.1 of the DSNE or Chapter 9 of the Lunar Sourcebook)

$$\rho = \rho_p(1-n). \tag{2.1}$$

The DSNE suggests using $\rho_p = 3.1$ g/cm^3 for the average particle density over the entire Moon. Otherwise, the typical highlands particle density is $\rho_p = 2.75 \pm 0.1$ g/cm^3 whereas the typical mare particle density is $\rho_p = 3.35 \pm 0.1$ g/cm^3.

The bulk density[1] as a function of depth, fit to Apollo data, is given by

$$\rho(z) = 1.92\frac{z+12.2}{z+18}, \tag{2.2}$$

where z is the depth in cm and ρ is in units of g/cm^3. At the surface ($z=0$), the density is 1.30 g/cm^3, and increases to 1.92 g/cm^3 for large depths. This expression is fairly reasonable down to 3 m (the limit reached by Apollo drill core samples). In order to get an up-to-depth average of the bulk density, take

$$\rho_{avg}(z) = \frac{1}{z}\int_0^z dz'\rho(z'), \tag{2.3}$$

[1] Found to follow the average particle density of 3.1 g/cm^3 for all depths with a porosity depth dependence following Table 1.

which gives

$$\rho_{avg}(z) = 1.92 \left[1 + \frac{5.8 \ln\left(\frac{18}{z+18}\right)}{z} \right]. \tag{2.4}$$

For example, the average bulk density of the regolith with a depth range of $0 - 60$ cm would be $\rho_{avg}(60)$ = 1.65 g/cm^3. This expression is useful for computing the ejected mass from a crater, given a crater depth z.

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