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Lunar near surface porosity: impact crater and projectile size-frequency distributions

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Crater counts on the lunar surface are widely used to estimate the absolute age of various areas. The size-frequency distribution (SFD) of craters should correspond to SFD of projectiles created impact craters. Recent data on terrestrial bolides in comparison with small ($D \leq 300$ m) lunar craters younger 100 Ma demonstrate the correspondence of crater and projectile SFD [1] provided the scaling law for porous target material (regolith) is used to recalculate crater size to projectile size [2]. Earlier the similar correspondence (within the accuracy limits of a factor of 2) has been established for craters larger a few km in diameter using the scaling law for non-porous targets. In the intermediate crater range (0.3 km $< D <$ n km) the usage of the porous scaling law gives surprisingly good fit between lunar impact crater SFD and near-Earth asteroid population estimated from astronomical observations and modeling [3]. This result attracts attention to the mechanical state of lunar rocks in the upper layer. Well-known regolith layer has thickness from 5 to 15 m. Cratering in regolith seems to be similar to the impact cratering in porous sand. The lower layer is more rigid mechanically resulting in concentric crater formation in $n \times 100$m crater diameter range [4]. Does it mean that for larger lunar craters one should use the non-porous scaling law (like it was implicitly assumed in many works – e.g. [5])? The review of previously published data on seismic sounding of the Moon show that the layer just under regolith has amazingly low velocity of longitudinal elastic waves about 1 km/s in the upper 1 km [6, 7, 8]. Such a low seismic velocities allow us to assume highly fractured and fragmented $\sim$1 km of near-surface lunar rocks. This fragmented state permits the presence of the appreciate macroporosity of near-surface lunar bedrocks. Impacts in porous rocks results in fast shok wave decay and enhanced energy conversion into heat due to dynamic closing of porous space. Despite the apparent low strength of porous

rocks dynamic effects may result in final crater size *smaller* than in more competent but non-porous rocks. This effect is partially masked in low-velocity experiments [9] but well expressed in the numerical modeling [10]. In the presented work we use the hypothesis of an appreciate porosity of the upper 1 km of near surface rock to interpolate the estimated projectile size between porous regolith layer (and "porous" scaling) for small craters and non porous scaling for craters deeper than the low-velocity $\sim$1 km layer. Resulted SFD for lunar projectiles fits pretty well with debiased NEA SFD [3]. It means that the lunar bombardment flux is nearly constant during the last $\sim$3 Ga. At the same time the lunar porosity effect results in the problem how to recalculate the lunar cratering chronology to Mars and Mercury. If the porosity vertical profile on these planets differs from the lunar one, the previously published recalculations [11] used the single (non-porous) scaling law should be heavily reconcidered. The study of the mechanical state of the upper km of the lunar crust is turned to be of a great importance for the comparative planetology.

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