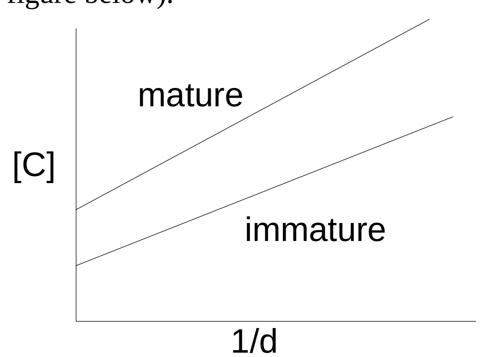
A NEW MODEL OF SIZE-GRADED SOIL VENEER ON THE LUNAR SURFACE Abhijit Basu[1] and David S. McKay[2], [1]Department of Geological Sciences, Indiana University, Bloomington, IN 47405 (basu@indiana.edu); [2]NASA-JSC, Houston (david.s.mckay1@jsc.nasa.gov)

Introduction. We propose a new model of distribution of submillimeter sized lunar soil grains on the lunar surface. We propose that in the uppermost millimeter or two of the lunar surface, soil-grains are size graded with the finest nanoscale dust on top and larger micron-scale particles below. This standard state is perturbed by ejecta deposition of larger grains at the lunar surface, which have a coating of dusty layer that may not have substrates of intermediate sizes. Distribution of solar wind elements (SWE), agglutinates, vapor deposited nanophase Fe^0 in size fractions of lunar soils and *ir* spectra of size fractions of lunar soils are compatible with this model.

A direct test of this model requires bringing back glue-impregnated tubes of lunar soil samples to be dissected and examined on Earth.

The Current Model and Lunar Soil Properties. The current gardening model calls for continuous comminution of target grains, turnover and perfect mixing of soil grains in all sizes in the top several millimeters, if not in the top centimeter, of the lunar surface in response to continuous micrometeoritic bombardment of the lunar surface [1,2]. The process, if continued for long enough a time without any perturbation, would lead to a homogeneous surface layer of lunar soil in which each grain would have an equal probability of being exposed to solar radiation. A consequence is that all lunar soil grains in this uppermost perfectly mixed layer would be coated with particles of solar radiation, i.e. with SWE that are implanted on grain surfaces. Because the specific surface area (= total surface area/mass) of grains of identical shapes (say spheres) increases linearly with decreasing size (~ grain diameter), concentration of SWE per unit mass in different grain size fractions should have a linear correlation with inverse size. And indeed such is the case as is seen in many studies of the submillimeter fraction of lunar soils (see plots in, for example, [3-6]). The graphs show that the distribution of SWE in lunar soils follow the general straight line equation of $C = v + md^{-1}$, where C = total element concentration in grain size 'd', v = element concentration inside the volume of soil grains regardless of size, d = grain diameter, and m = surface concentration of element of interest [see 7 for a detailed treatment].

In reality, the system is not so perfect. Micrometeoritic bombardment not only comminutes and stirs (~ gardens) but also agglutinates as impact melts scavenge soil grains before quenching [8]. Freshly formed agglutinates, larger in size than the grains from which they had formed reside on the surface (and suffer higher doses of irradiation) until they too are comminuted and mixed with the rest; in addition, intermittent larger impacts eject material from below the gardened zone bringing up larger and less irradiated grains to the surface [9, 10]. Products of gardening are thus perturbed by agglutination [11, 12]. A consequence of agglutination is that surface-correlated SWE in smaller grains get incorporated inside agglutinates and become volume-correlated. The effect of this on any 'element-concentration *vs.* inverse grain size' plot is to increase 'v' in the equation above, and to increase the surface-concentration as well. Thus, 'v' and 'm' are greater in more mature soils (that contain more agglutinates) than in less mature soils (see figure below).



Schematic distribution of SWE in size fractions of lunar soils [11]

The few studies of agglutinate separates in different size fractions of submillimeter grains do not, however, show much larger volume correlated components ('v') although the total concentrations of SWE are higher [5, 7, 13]. Additionally, some of the near 1mm sized, i.e. larger agglutinates have anomalously high concentrations (mass normalized) of SWE relative to smaller agglutinates. We conclude that the gardening model with respect to solar wind element implantation and other surface correlated components needs further modification. We suggest that the model of gardening of lunar soils [1, 2] is applicable possibly down to about millimeter sized grains but that additional processes modify the finer size fractions.

Deposition of Submillimeter Ejecta. If ejecta distribution from an impact is controlled by a uniform flow-field, deposition in a friction-free medium, e.g. on the Moon or Mercury where there is no atmosphere, would not lead to any size sorting.

However two other mechanisms known to occur on the moon may lead to size sorting and to preferential concentration of the fine-grained fraction. Impacts vaporize part of the projectile and target, and this expanding impact vapor cloud may preferentially entrain small particles and separate them from larger ones. Small particles may be carried higher above the surface by this expanding gas cloud, and consequently be the last particles to fall back, covering coarser particles. Some evidence that this process exists is found in the coating of well-sorted fine grains on particles of ropy KREEP glass [14]. The relatively well-sorted nature of the orange volcanic glass may, in part, result from size-sorting in the erupting volcanic gas cloud [15]. Electrostatic attraction/repulsion may also size-sort small grains during impact gardening. In addition, as the terminator region rotates over the Moon, small soil grains (perhaps up to tens of microns) are levitated in proportion to their mass and the strength of the electrostatic field around each grain [16-18]. As the terminator region moves away and charging reduced, grains are deposited back in inverse proportion of their mass, i.e. sorted by size with nanoscale dust on top and larger grains at the bottom. In the ideal case, the vertical size sorting will be linear against 1/d. The result of both these processes is that larger grains may get covered on top by smaller grains. While either vapor wind or electrostatic levitation could occasionally clean dust from larger rocks, the dust would simply be deposited on other rocks; the net result would be to concentrate the average abundance of very fine particles at the surface.

Discussion. We suggest that the top millimeter or two of the lunar surface is size-sorted but perturbed by gardening *a la* Gault et al. [1] and Arnold [2] and modified by agglutination *a la* Wendell and McKay [10]. This would lead to higher irradiation of and vapor deposition on the smaller grains because they exist on top of others and a gradual decrease in irradiation of larger sizes. If so, this model of size-graded deposition can explain the distribution of SWE and vapor deposited material rather than calling on strictly stochastic properties of the currently accepted regolith gardening model.

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