FRACTIONATION TRENDS IN AN ARTIFICIAL REGOLITH: EXPERIMENTAL RESULTS; A.M. Therriault,[1] M.J. Cintala,[2] and F. Cardenas;[3] [1]Department of Geosciences, University of Houston, TX 77004; [2]Code SN21, NASA JSC, Houston, TX 77058; [3]Code C23, Lockheed ESC, Houston, TX 77058.

The compositions of bulk lunar soils differ distinctly from those of the finest grain-size fractions, which has been attributed by some to differential comminution of local rocks, and by others to grain-size dependent ballistic transport over substantial lateral distances.[1,2,3,4,5] More recently, a variety of theoretical and experimental investigations have been pursued to describe the comminution products of well-characterized regolith analogues subjected to multiple impacts. It has been demonstrated that *in situ* comminution can produce fractionation trends akin to the lunar observations.[6] These experimental trends, nevertheless, were exclusively based on polymineralic, lithic fragments composing the initial regoliths. Judging from the modal composition of lunar soils,[7] however, monomineralic detritus constitutes a substantial modal fraction in lunar regoliths, frequently being as abundant as lithic fragments. Clearly this mineral detritus is subjected to additional comminution. Does it comminute and fractionate like lithic regolith components? What is the role of monomineralic fragments in producing the grain-size dependent, lunar fractionation trends?[3] To this end, multiple-impact experiments have been conducted, using a particulate target, composed of mineral fragments in carefully controlled modal proportions.

Experimental Procedures: Single-crystal grains of feldspar (mainly Ca-poor and Na-rich, *i.e.*, antiperthite and albite), pyroxene (Ca- and Mg-rich augite), and olivine (forsterite, Fo_{80-95}) initially 2-4 mm in size were mixed to simulate a fragmental, lunar gabbroic anorthosite. This target was impacted 25 times with stainless-steel projectiles (diameter = 3.2 mm; mass = 0.128 g) at a nominal velocity of 2.4 km/s, and sieved after shots 1, 2, 3, 5, and every fifth shot thereafter. Each size fraction (0.5-1 mm, 0.250-0.5 mm, 0.125-0.250 mm, 0.063-0.125 mm, 0.044-0.063 mm, 0.020-0.044 mm, <0.020 mm) was sampled after sieving. Glass beads and grain mounts were made of the following size fractions: 0.125-0.250 mm, 0.044-0.063 mm, 0.020-0.044 mm, and <0.020 mm. Electron microprobe analyses of glass compositions were performed at 30 nA, 15 kV, and under a beam with a raster size of 40μm; 30 to 45 points were analyzed on each bead. The modal composition of the grain fractions were obtained by 200 grain-counts under the same conditions as above.

Results: As observed in previous experiments, the feldspars comminuted more readily than the mafic components. Feldspar -- initially present at 80% (weight) -- typically represented 90-95% of the 0.125-0.250-mm fraction; augite (initially at 15%) and forsterite (initially at 5%) were depleted to 5-10% to 1-4%, respectively. This fractionation is obvious in Figures 1 and 2 in the earliest samples analyzed, but the relative enrichments and depletions changed somewhat with time. Bulk chemical analyses reveal corresponding enrichments in both Al_2O_3

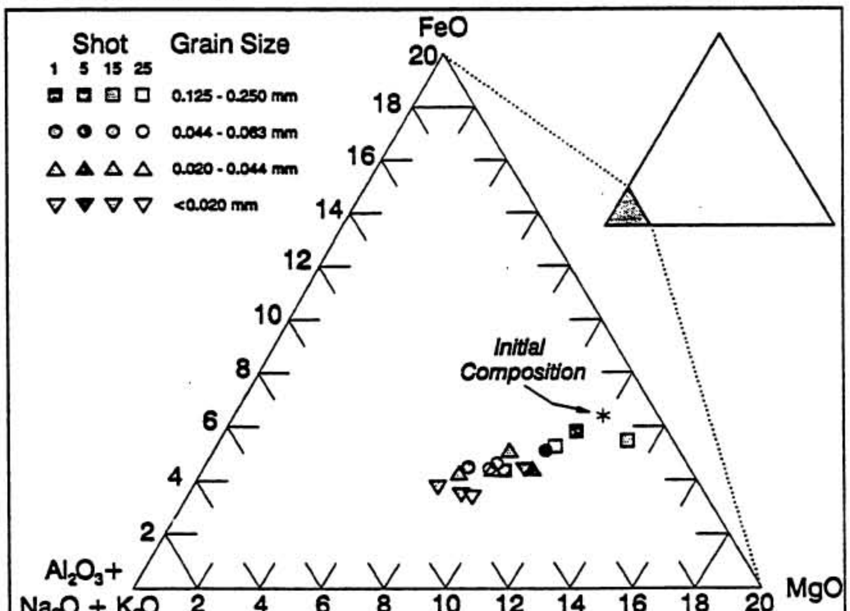

Figure 1. Lower portion of an AFM diagram, illustrating the variations in composition of the different shots and grain sizes with respect to the initial composition of the bulk regolith.

and Na_2O+K_2O, while FeO, MgO, and CaO were depleted. An increase in felsic components is apparent in Figure 1 as a function of decreasing grain size. Relative to the initial composition, all fractions decrease in FeO and MgO content with time, except for shot 15/grain size 0.125-0.250 mm, which increases in MgO content. This sort of random variation early in a series is typical of such experiments.[8] Here, the finest grain-size, having experienced the highest shock stresses, is less random and represents the most regular variation in composition with time. The results shown in Figure 2 are similar to those in Figure 1, including that for Na_2O+K_2O, which shows a depletion that may be due to volatilization of Na and K from the samples during preparation of the glass beads and during microprobe analyses. These trends correspond overall to the results of earlier experiments, indicating a depletion in pyroxene (CaO, MgO, and FeO) and olivine (MgO and FeO), and an enrichment in feldspar (Na_2O and K_2O).

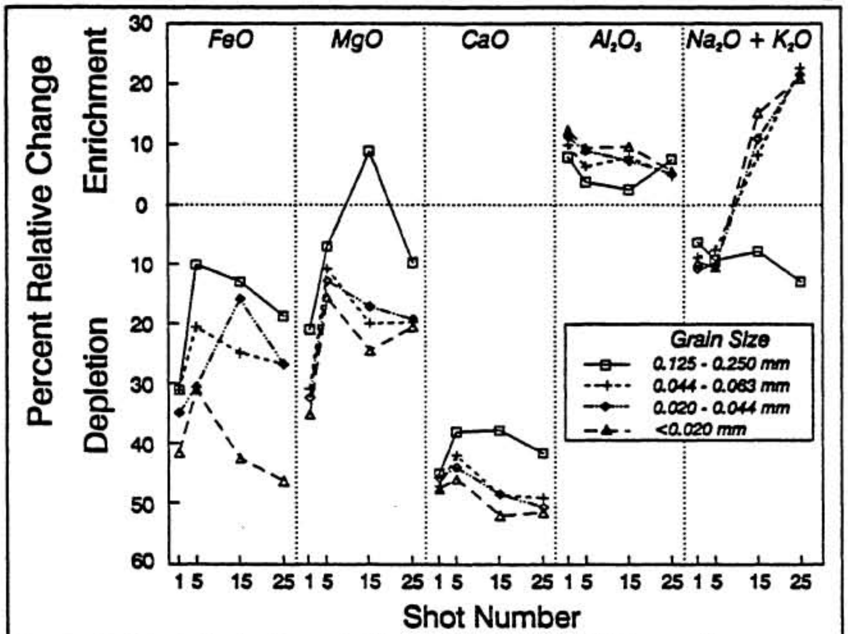

Figure 2. Variations in the abundances of oxides relative to the average initial composition.

Discussion: The results of these experiments, as did earlier findings,[6,9] illustrate that differential comminution, even at relatively low velocities, is capable of producing fractionation in the finest grain-sizes. In addition, they indicate that such fractionation can occur in regoliths composed of monomineralic fragments, and therefore does not require lithic properties, such as dissimilar shock-impedances along grain boundaries, to be effective. Although existence of the process cannot be denied, a necessity does not exist for prominent lateral and vertical transport of some fine-grained components otherwise "foreign" to a lunar soil-sampling site, as postulated by some workers on the basis of multivariate chemical mixing models. The next experiments will be conducted at different velocities and with other, increasingly more mafic, compositions.

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