DIFFERENCES IN ELEMENTAL DISTRIBUTIONS IN THE SIZE FRACTIONS OF MARE- AND HIGHLANDS-TYPE SOILS. W.V. Boynton, K.L. Robinson, P.H. Warren and J.T. Wasson, IGPP, University of California, Los Angeles, CA 90024

In continuation of our study of elemental distributions in size fractions of lunar soils, we have studied a mare type soil, 15100. Like other soils collected at station 2 near St. George crater, 15100 consists mainly of three components, olivine- and quartz-normative basalts and low-K Fra Mauro basalt; the green-glass content is small. As in our other recent experiments (1), the sieving was performed after neutron irradiation to minimize contamination. Volatile element concentrations in the different size fractions are plotted in Fig. 1a. Ignoring the coarsest size fraction in which the small number of particles may lead to sampling errors, it can be seen that Zn and In concentrations increase monotonically with decreasing grain size; Cd and Ga increase only in the finer size fractions but the difference between Cd and Zn is not statistically significant.

These volatile element concentrations can be interpreted as a mixture of a volume-related component having volatile element concentrations roughly independent of grain size, and a surface-related component having concentrations proportional to specific surface area. The volatile element distributions seen in 15100 are similar to those found in highlands soils from Apollo 16 (1): concentrations of Zn, Cd and In increase with decreasing grain size leading to roughly parallel slopes in the finer fractions; Ga shows a smaller increase. The range in concentration of Cd and Zn between the coarsest and finest fractions are significantly different between the two sites, however. In the Apollo 16 samples, Cd in the finest fraction was enriched over the coarsest fraction by factors of 14 and 26 in 61220 and 63500, respectively; in 15100 the enrichment is only a factor of 4. In the Apollo 16 soils 70-80% of the Cd was surface related, but in 15100 only ∿30% of Cd is surface related. Bulk concentrations of volatiles In, Zn, and Cd in 15100 are also lower by about a factor of two relative to the Apollo 16 soils.

This volatile element distribution in lunar soils appears to have been established by a mechanism other than that suggested by Criswell (2). He noted that if mean surface exposure times are equal for all particle sizes, exposure to a unidirectional flux should lead to a volume-correlated rather than a surface-correlated distribution. He proposed that the surface correlation of the rare gases results from saturation effects in the larger grain sizes. However, if the volatile metals were deposited as a condensate on grain surfaces, saturation is not strictly possible.

As discussed by Boynton et al. (1), Criswell's model can also not adequately explain the rare gas data. Since Ar/Kr and

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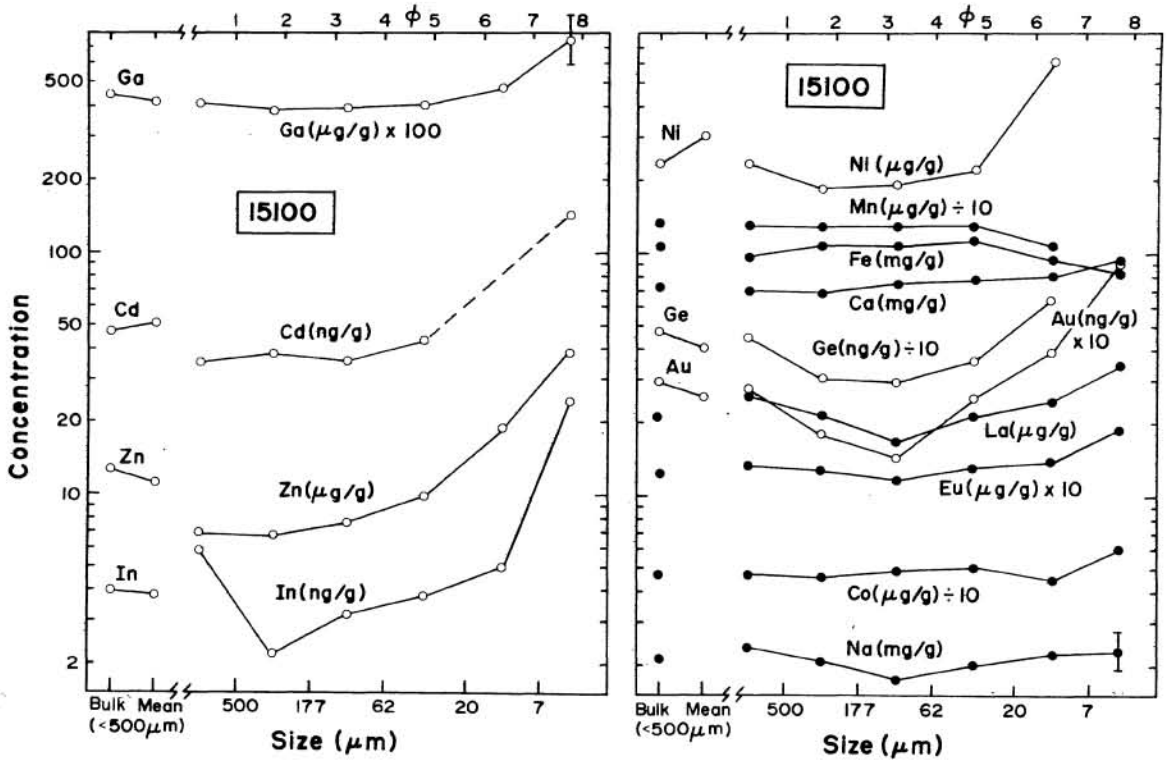

Fig. 1. Elemental concentrations in size fractions of soil 15100. Volatile elements Zn, Ga, Cd and In show an enrichment in the finer fractions similar to that observed in Apollo 16 soils but the magnitude of enrichment is less. Siderophile elements Ni, Ge and Au show enrichments in the finer fractions; in Apollo 16 soils the siderophiles were enriched in the 80-300 μm range.

Kr/Xe ratios in lunar soils are nearly equal to the solar values (3), it is unlikely that appreciable Xe saturation has occurred, yet Xe concentration is inversely correlated with grain size and the slope of its distribution is similar to that for Ar.

Another explanation is necessary to explain both the volatile-metal and rare-gas distributions. Of alternatives considered by Boynton et al. (1), a model in which the larger grains are shielded by adhering finer grains appears the most plausible.

The size distribution of siderophiles and lithophiles also differ between Apollo 16 and 15100. Fig. 1b shows our data for a number of these elements. The extralunar siderophiles Ni, Ge and Au are depleted in the middle size fractions relative to both the finest and coarsest fractions. The enrichment of the siderophiles in the coarsest fraction may not be significant due to sampling but the enrichment in the finer fractions is genuine

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and confirms the enrichment of siderophiles in finer fractions of mare soils studied by Ganapathy et al. (4) and Duncan et al. (5). In the Apollo 16 soils, the siderophiles were slightly enriched in the middle size fractions; the enrichments were paralleled by Co, a siderophile of predominantly lunar origin. In 15100, Co is nearly independent of grain size. Boynton et al. (1) noted that the enrichment of siderophiles in the 80-300 μm size range paralleled the agglutinate size distribution and suggested that the enrichment might be caused by a reduction and scavenging of both lunar and extralunar siderophiles accompanying Fe reduction during agglutinate formation by the Housley et al. (6) mechanism. Alternatively, it was suggested that the increase might indicate that metal grains were more abundant in this size range. No data was available to distinguish between these alternatives. Soil 15100 has nearly the same agglutinate content as 63500 (42%, 125-250 μm vs 44.6%, 90-150 μm; (7)) which indicates either that the siderophile distribution in Apollo 16 soils was not related to agglutinate formation or that the relationship of siderophiles to agglutinates differs at the different sites.

In contrast to the Apollo 16 soils, the lithophile element concentration is not independent of size. Elements concentrated in pyroxenes and olivines, e.g. Mn and Fe, decrease by about 25% in the finest fractions whereas the KREEP component as indicated by La increases in these fractions. Evensen et al. (8) also attributed an enrichment of K, Rb and Ba in the finest fractions to excess KREEP. The remarkable homogeneity of the Apollo-16 soil lithophile element distribution with size may reflect a more extensive gardening at the older Apollo-16 site. The more labile volatiles may preserve their surface correlation by repeated volatilizations and depositions.

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