AGGLUTINATES: NOBLE GAS AND ELEMENT DISTRIBUTION IN GRAIN SIZE FRACTIONS OF THE APOLLO 15 SOIL 15601.

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A major constituent of lunar soils are agglutinates which are by definition aggregates of crystalline grains and lithic fragments bonded together by glass. The agglutinates are formed during micrometeorite impacts (1), the concentration of these welded particles within a bulk soil is a measure of the soil maturity. Agglutinates have high concentrations of solar noble gases (2-4) which cannot be explained by direct solar wind implantation. Also chemical fractionations between agglutinates and their parent materials have been reported (5).

In an attempt to investigate the importance of agglutinates for the noble gas record of a lunar bulk soil we have determined the noble gas concentrations in a suite of grain size fractions of bulk and agglutinate separates of soil 15601. These measurements were accompanied by multielement analyses of the same agglutinate fractions.

Fig. 1 shows a comparison of noble gas concentrations in agglutinates and bulk grain size fractions. It is evident that the process of agglutinate formation fractionates the light and heavy noble gases: The concentrations of trapped Ar, Kr and Xe in all grain size fractions is a factor of 2 to 2.5 higher than in the respective bulk sample. He and Ne, however, are enriched only in the largest grain size fractions of agglutinates by about 70%.

Fig. 2 shows as an example from both groups the variation of the concentration of 4-He and 36-Ar with grain diameter in bulk and agglutinate fractions. If only surface-correlated gases were present a linear anticorrelation between concentration and grain diameter should be observed. The convex form of these curves is, however, indicative for a mixture of surface and volume correlated components (6). The curve through the 36-ArAgg points is represented by

\[ C(d) = S(d/d_0)^{-1} + V \]

with \( d_0 \): An arbitrary reference grain size (100 \( \mu \)m)
\( S \): The surface correlated component in grain size \( d_0 \) (7 \( \times \) 10^{-5} cc/g)
\( V \): The volume correlated concentration (1.4 \( \times \) 10^{-4} ccSTP/g)

These measurements show that the heavy noble gases in mature soils are determined by the gas concentrations in the agglutinates. Their volume-correlated component - incorporated during the agglutinate formation - is also responsible for the deviations from the theoretical concentration versus grain diameter correlation of solar gases in many lunar bulk soil samples. The retentive ilmenites in lunar soils have high concentrations of He and...
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Ne, therefore, the volume-correlated component in agglutinates of the light noble gases becomes important only in soils with low ilmenite content (7).

Some of the chemical data are presented in Fig. 3. It shows that the mafic elements like Fe, Sc or Mn are depleted in the small grain size fraction compared to the coarse fractions and the bulk. Feldspathic and incompatible elements, however, are enriched in the finer agglutinate fractions. Evensen et al. (9) have shown that the fine bulk fractions of 15531 (also collected at Station 9A) are enriched in K, Rb, Sr and Ba. This has been explained by an admixture of fine grained, trace element rich, glassy mesostasis. The trends observed in the agglutinate fractions may also be explained by a magnetic fraction consisting of fine material of mesostasis and/or KREEP, however, also some fine material of feldspathic composition must be present. Recently, Pillinger et al. (10) described a mechanism of element fractionation by preferential sputtering of oxygen atoms by the solar wind. This effect could complement the addition of "magic" components as a source for element fractionation between lunar grain size separates.

Fig. 1: Comparison of trapped noble gas concentrations in grain size fractions of agglutinate and bulk samples.
Fig. 2: Concentration of $^4\text{He}$ and $^{36}\text{Ar}$ vs grain diameter $d$ for bulk and agglutinate samples. The data can be fitted to curves which represent a mixture of surface- and volume-correlated components.


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