VOLATILITIES OF TRACE ELEMENTS IN MINERALS AND AGGLUTINATES OF SAMPLE 75080 INVESTIGATED BY HEATING EXPERIMENTS. J. Sörensen*, F. Wegmüller*, U. Krähenbühl*, and H.R. von Gunten*+, *Anorganisch chemisches Institut, Universität Bern, CH-3000 Bern 9 and +Eidg. Institut für Reaktorforschung, CH-5303 Würenlingen, Switzerland.

In our earlier work on the distribution of trace and major elements in separated mineral and agglutinate fractions of Apollo-17 soils (1-5) it was proposed that volatilization and recondensation processes lead to an enrichment of volatile elements on surfaces of grains. This surface deposition was deduced from the observed anticorrelation of concentrations of trace elements vs. grain-sizes in the fractions containing minerals, whereas in the agglutinates only limited information was obtained so far on surface deposits. Furthermore, it is very difficult to estimate the temperatures of volatilization from these experiments.

In order to obtain results on these aspects heating experiments were performed with soil sample 75080 which has been investigated in our earlier work. The sample was irradiated prior to handling in order to reduce contamination. It was then separated into grain-size fractions using the techniques described in Refs. (5, 6 and 7). Several of the mineral and agglutinate fractions, thus obtained, were mixed with inert B_4C-powder of similar grain-sizes. They were heated in a quartz tube at temperatures between 130° and 1000°C. The volatilized elements were transported in a He-gas stream and were deposited on charcoal at room temperature. They were separated from each other in a second step by reheating at 1000°C and were subsequently transported with N_2/Cl_2-gas and deposited on charcoal in a linear temperature gradient between 1000° and 10°C. The charcoal was dissected and measured on Ge(Li) detectors.

Two groups of volatilization experiments were performed: i) Time dependency; the samples were inserted in an oven at 1000°C for time spans between 30 s and 10 hours. The time sequence of the heating was deduced from reproducible results obtained with anorthosite samples containing ^{65}Zn. These samples showed different release patterns for Zn on surfaces and in the interior. ii) Temperature dependency; the samples were heated in steps from 130° to 1000°C.

Fig. 1 shows the time dependency for the volatilization of Zn in the mineral fraction of 15-75 μm and in two agglutinate fractions with grain-sizes of 15-75 μm and 150-350 μm. It is evident that a very large portion of

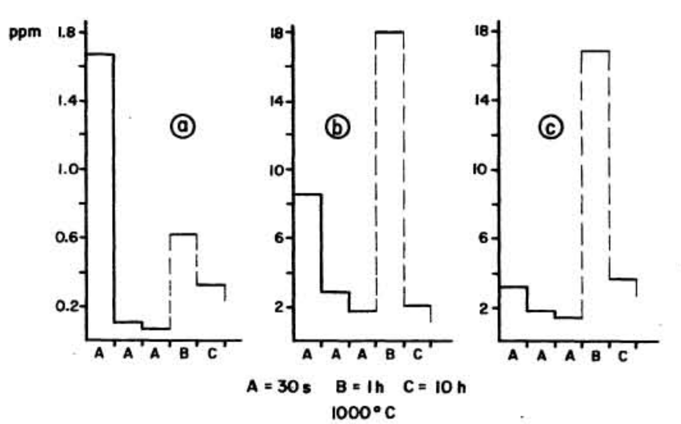

Fig. 1

Time dependent release of Zn at a temperature of 1000°C. (a) Minerals with grain-sizes 15-75 μm, (b) agglutinates 15-75 μm, (c) agglutinates 150-350 μm. Subsequent heating times: A = 30 s, B = 1 hour, C = 10 hours.

Zn volatilizes in the first 30 s. The rate of evaporation decreases then with increasing times. The first rapid evolution corresponds undoubtedly to Zn deposited on the surfaces of the grains, whereas the slower release at later times reflects diffusion from the interior (volume). As expected from our earlier experiment (4, 5) the surface-to-volume ratio for the distribution of Zn decreases from the minerals (15-75 μm, Fig. 1a) to the agglutinate fraction 15-75 μm (Fig. 1b) and to the agglutinates with sizes of 150-350 μm (Fig. 1c). The surface-to-volume ratio in the minerals agrees well with that obtained in our earlier work (4, 5).

An analogous evaporation behaviour at 1000°C was also observed for Br, Cd, Hg and Se. Two agglutinate size fractions of 15-75 μm gave similar results. However, with the exception of Zn the recovered amounts of the investigated elements were smaller than those measured in Refs. (4, 5).

The results of the time dependent release experiments at 1000°C demonstrate for the first time directly that these volatile elements are enriched on the surfaces of the agglutinates as well as of the minerals.

Fig. 2 shows the temperature dependency in the volatilization of Hg in the mineral and agglutinate size fractions of 15-75 μm. The heating sequence is given in the figure caption. Hg evaporates significantly already at 130°C. The integral amount of volatilized Hg increases with temperature. Above 450°C no release was observed in the mineral fraction, whereas in the agglutinates

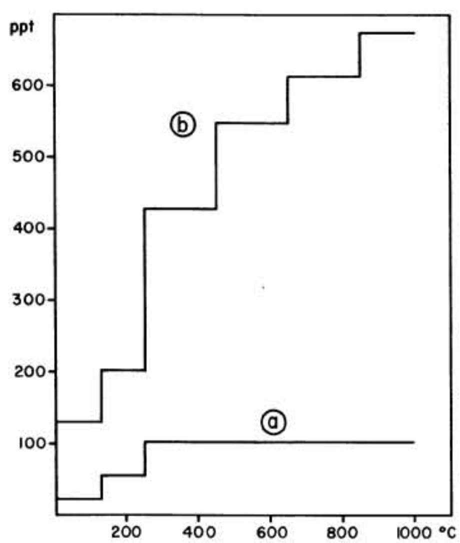

Fig. 2

Temperature dependent release of Hg in the grain-size fraction 15-75 μm. (a) Minerals, (b) agglutinates. Heating sequence: 12 h at 130°C, 6 h at 250°C, 1 h at 450°C, 30 min at 650°C, 10 min at 850°C and 2 min and 10 h at 1000°C.

it continues up to 1000°C. However, only about 50 % of the total Hg (5) was recovered, the missing part has not been located yet. These results indicate that a significant volatilization of Hg occurs on the moon by solar heating of the soils ($t \leq 130°C$) during lunar days. This is in agreement with observations reported by Jovanovic and Reed (8).

For Zn and Se a significant evaporation was noted above 450°C. Br and In were observed at temperatures > 650°C. Due to a limited sensitivity with the technique of thermochromatographic separation it can not be excluded that these elements are volatilized to a small extend at lower temperatures.

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Conclusions

i) Volatile elements are deposited on the surfaces of minerals and agglutinates. ii) Hg is volatilized significantly at $t \leq 130^{\circ}C$. It is therefore volatile during lunar days and moves around on the lunar surface. iii) Significant amounts of Zn and other elements are volatilized at $t \geq 450^{\circ}C$. It can not yet be excluded that small traces of these elements are also volatile during lunar days. iv) Volatilization and recondensation processes are very important for the distribution and redistribution of elements on the moon. These processes occur already at moderate temperatures.

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References

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