

Diss. ETH 5483

**ON THE ORIGIN OF HELIUM, NEON, AND ARGON
ISOTOPES IN SIEVED MINERAL SEPARATES FROM AN
APOLLO 15 SOIL**

A Dissertation submitted to the
SWISS FEDERAL INSTITUTE OF
TECHNOLOGY, ZÜRICH
for the degree
Doctor of Natural Sciences

Presented by

U R S F R I C K
dipl. sc. nat. ETH
born on June 3, 1943
from Zürich and Mettmenstetten ZH,
Switzerland

Accepted on the recommendation of
Prof. Dr. P. Signer, Zürich
Prof. Dr. L. Schultz, Mainz

Clausthal-Zellerfeld
Bönecke-Druck
1975

5. SUMMARY AND CONCLUSIONS

This investigation of noble gases in grain-size fractions of several mineral separates from one soil (15421) yield the following results :

(1) For all separates the extrapolated (loss independent) volume correlated $^{21}\text{Ne}/^{38}\text{Ar}$ ratios are close to those calculated from target chemistry and production rates. Spallogenic ^3He as well as radiogenic ^4He show large losses in 15421 green glass fractions. Such losses from feldspar are consistent with model calculations of diffusive loss from homogeneous spheres although more than 99% would have been lost from grains with $r = 50 \mu\text{m}$. Two models with grain-size dependent losses of spallogenic Ne are presented to explain the unusually high apparent $^{20}\text{Ne}/^{21}\text{Ne}$ and $^{22}\text{Ne}/^{21}\text{Ne}$ ratios of surface correlated Ne.

(2) In feldspar the isotopic composition of spallogenic Ne suggests the existence of solar cosmic-ray proton produced Ne nuclides. The lack of Mg in this mineral makes it suitable to detect such a "low energy spallation" component due to the low $^{21}\text{Ne}/^{20}\text{Ne}$ and $^{21}\text{Ne}/^{22}\text{Ne}$ ratios produced from Al and Si target atoms.

(3) Solar gases show characteristic elemental distribution patterns for each mineral which are similar to those observed in other soils. Noble gas abundance pattern of bulk soils are thus to be understood in terms of the bulk mineralogy. Specific retentivities in individual mineral separates result from processes connected with solar irradiation, perhaps different response to radiation damage.

(4) Estimated noble gas fluxes accompanying solar flares are sufficient to introduce significant surface concentrations of He, Ne, and Ar. For different minerals, specific retentivities for solar particles of different energies may lead to various proportions of noble gases from solar wind and solar flare origins. Therefore, in different minerals, the isotopic ratios of the surface correlated components can be understood as various mixtures of noble gases from these two sources (sw and sf). Ne and

Ar data suggest that the isotopic composition of gases from solar wind and solar flare origin is somewhat different, with a heavy particle enrichment of at least 2-5 % per mass unit in the latter.

(5) In the case of feldspar a number of features of surface correlated gas can be explained by a solar particle distribution in grains reaching to a model depth of about 10 μm . The concept of such a relatively thick, gas rich layer is successful for quantitative modeling of the feldspar data, but one should use caution in interpreting this in terms of a physical depth.

(6) For feldspar, Ar data might be understood in terms of a single (constant) volume correlated component and two surface correlated components which can be identified as equilibrated solar wind and non equilibrated solar flare Ar. The latter appears to be in the stage of accumulation in small grain-size fractions ($d < 100 \mu\text{m}$), whereas for large grains ($d > 200 \mu\text{m}$) equilibrated surface concentrations from both sources are indicated. If no substantial loss of spallogenic Ar has occurred, a solar wind $^{36}\text{Ar}/^{38}\text{Ar}$ ratio of 5.53 ± 0.03 can be evaluated with a solar flare $^{36}\text{Ar}/^{38}\text{Ar}$ ratio less than 5.09 ± 0.02 . Both values represent upper limits for the isotopic composition of solar wind and solar flare Ar.