

**Solar Ne and Ar in Kapoeta Plagioclase: SW- and SEP-Components Identical to those in Minerals from the Lunar Regolith.** A. Pedroni(\*), H. Baur, P. Signer and R. Wieler NO C61, ETH Zürich, CH-8092 Zürich, Switzerland. (\*) present address: MPI für Chemie, Saarstrasse 23, D-6500 Mainz, Germany.

**Introduction:** Previous etching studies of lunar plagioclase (1,2), pyroxene (2,3,4) and ilmenite (3,4) indicated besides GCR-produced noble gases the presence of two isotopically distinct noble gas components, both originating from the solar corpuscular radiation. He, Ne and Ar of one component resemble isotopically the solar gases detected in the aluminum foils exposed to the solar wind during the Apollo missions (c.f.5), whereas the second one is isotopically heavier. Gases released in the early etching steps were consistently enriched in solar wind type gases (SW) and the heavy component dominated in later steps. Therefore, it was concluded that these gases were implanted at energies above those of solar wind ions. Without particular reason to imply a specific origin, the heavy components were termed "SEP-gases" to indicate a source of some kind of "Solar Energetic Particles". Isotopically similar gases were also observed by Frick et al. (6) as well as by Becker and Pepin (7) in their experiments with oxidation and pyrolysis as mode of stepped gas extraction. These authors proposed an alternative explanation, namely diffusive fractionation during migration of solar wind implanted gases into the exposed grains.

To seek an answer to the issue of distinct component versus altered SW gases, we investigated solar gases in the howardite Kapoeta, a meteorite breccia originating from an asteroidal regolith. As such, it is rather immature and was exposed to the solar ions at a larger mean distance from the sun. Both differences are expected to reduce possible isotopic alterations between incoming and retained gases in Kapoeta as compared to lunar soils, no matter whether the alterations result from thermal diffusion or saturation. Clearly, plagioclase grains are best suited for comparison because they have the lowest retentivity of all minerals commonly occurring in lunar soils.

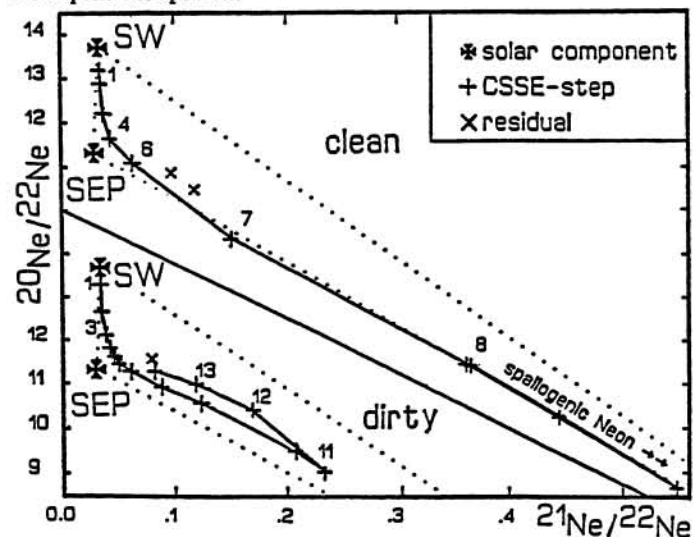
**Samples and experimental procedure:** We examined two plagioclase samples: The "dirty" sample (173.8 mg) was prepared by sieving (50-200µm), heavy-liquid and magnetic separation. The "clean" sample (146.7 mg, 75-300µm) was obtained in the same way and in addition improved by handpicking of contaminated grains. Both samples were etched in several steps by HNO<sub>3</sub>. To free conveniently measurable gas amounts, the duration of the etching was progressively prolonged and, when it became necessary, rendered more aggressive by raising the temperature of the reaction vessel up to 60 °C. The etching was carried out in the CSSE-line described by Wieler et al. (2), who also gives details about the mass spectrometric analyses for element and isotope abundances. The residues left after the etching sequences were pyrolysed to determine the compositions of the remaining gases.

**Results and discussion:** The isotopic compositions of the Ne released in the individual steps are shown in Fig.1. The difference between the "clean" and "dirty" sample (upper and lower panel, respectively) is attributed to contaminations of the plagioclase by material which is more resistant to etching than the plagioclase itself. The contaminants release their gases predominantly under the etching conditions used towards the end of the plagioclase etching. Thus, the gas release from the

Table 1. Best estimates of the isotopic compositions of SW and SEP Ne and Ar as derived from CSSE-studies of lunar soil minerals (1-4). The compositions of GCR produced spallogenic gases were derived from a grain size suite of plagioclase grains from Kapoeta (8). They are similar to those reported by Lugmair et al. (9) for plagioclase from lunar rock 76535.

Comp. Ref.	SW (3,5)	SEP (3,8)	GCR (8)
$^{20}\text{Ne}/^{22}\text{Ne}$ ±	13.7 0.1	11.3 0.2	0.80 0.05
$^{21}\text{Ne}/^{22}\text{Ne}$ ±	0.0327 0.0004	0.0299 0.0005	0.79 0.05
$^{36}\text{Ar}/^{38}\text{Ar}$ ±	45 10	45 10	1.5 0.3
$^{40}\text{Ar}/^{38}\text{Ar}$ ±	5.48 0.05	4.9 0.1	0.65 0.05

Figure 1: Ne correlation diagram. The dotted lines connecting two of the three components listed in Table 1 give the positions of data points of mixtures of the two respective components.



resistant minerals cause a reversal of trend observed in the earlier steps. The "clean" sample, where most contaminated grains were removed, shows no such reversal (upper panel of Fig. 1). The position of the data points for the residuals in Fig. 1 also indicate the survival of SW gases in the retentive material.

We interpret Fig. 1 to show that the initial etching steps release mixtures of SW- and SEP-Ne with progressively larger SEP and GCR contributions. The "clean" sample releases, after depletion of the shallowly implanted SW-Ne, mixtures of SEP- and GCR-Ne. The "dirty" sample always releases Ne with a SW-contribution, presumably from the resistant contaminant. The close match between the Ne in Kapoeta and the mixing lines based on lunar soil data shows that the isotopic compositions of all components, the SW-, SEP- and GCR-Ne in Kapoeta plagioclase are the same as those in lunar plagioclase. Remembering the different exposure conditions of the two types of plagioclase, this similarity speaks against the explanation of the SEP-Ne as being altered SW-Ne (6,7). In this context it is essential to note that Rao et al. (10) examined solar gases in Kapoeta plagioclase by pyrolysis of residuals left after various degrees of etching -without control of the gases freed-and deduced a  $^{20}\text{Ne}/^{22}\text{Ne}$  ratio of  $11.6 \pm 0.1$ . Based on our experience, we attribute this value to traces of SW-Ne in retentive material surviving the etching.

The correlation between the  $^{20}\text{Ne}/^{22}\text{Ne}$  and  $^{36}\text{Ar}/^{38}\text{Ar}$  ratios are shown in Fig. 2. The dotted lines are again mixing lines of two components each. The components are assumed to have the isotopic compositions given in Tab.1. Fig. 2 illustrates that not only the isotopic compositions of the three Ne-components are the same in Kapoeta and lunar plagioclase, but also SW- and SEP-Ar.

In contrast to the isotopic compositions, the elemental compositions of solar gases retained in Kapoeta plagioclase are quite different from those in lunar plagioclase. Wieler et al. (2) reported a mean ratio for solar  $^{20}\text{Ne}/^{36}\text{Ar}$  around 2 in lunar plagioclase whereas we observed a value of  $22 \pm 5$  in the Kapoeta plagioclase. This value is much closer to the accepted SW ratio of  $45 \pm 10$  (5) and leads to the following important implications: • As expected, losses of implanted Ne from Kapoeta plagioclase are much smaller than from lunar soil plagioclase, at least relative to those of Ar. • Despite a ten times smaller relative fractionation between Ne and Ar, the isotopic compositions of SW- and SEP-Ne are within our experimental resolution the same in plagioclase from lunar and asteroidal regolith.

**Conclusions:** Solar Ne and Ar retained in plagioclase in the asteroidal regolith from which Kapoeta originates contain mixtures of the same two components as reported previously to occur in minerals from lunar soil samples (1-4). Again, the surface region of the individual grains contains noble gases with isotopic signatures close to the SW-values deduced from the Apollo Solar Wind Composition Experiment (5). The isotopically heavier component becomes again apparent in later steps with more aggressive etching conditions. It is detected to nominal depth of up to several tens of micrometers (1,8) and presumably originates from more energetic particles, such as suprathermal solar ions. The isotopic signatures of this component is identical to those of the SEP gases found in lunar soil minerals (1-4). The mean  $^{20}\text{Ne}/^{36}\text{Ar}$  ratio of the solar gases in plagioclase from Kapoeta is about ten times higher than in plagioclase from lunar soils. Yet, despite different degrees of Ne losses, the isotopic ratios of the SEP-Ne are the same in both carriers.

We take this study to support our contention that SEP-type gases are a true, genuine component rather than isotopically fractionated SW gases, as proposed by Frick et al. (6) as well as Becker and Pepin (7). Note, however, that the problem of the high abundance of the SEP-gases relative to the SW-gases pointed out earlier (2) is still not resolved.

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Figure 2: Correlation between the isotopic composition of Ne and Ar. The dotted lines represent mixtures of two of the three components listed in Table 1.

